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WORLD PETROLEUM

NEW YORK AND LONDON

JUNE 1939

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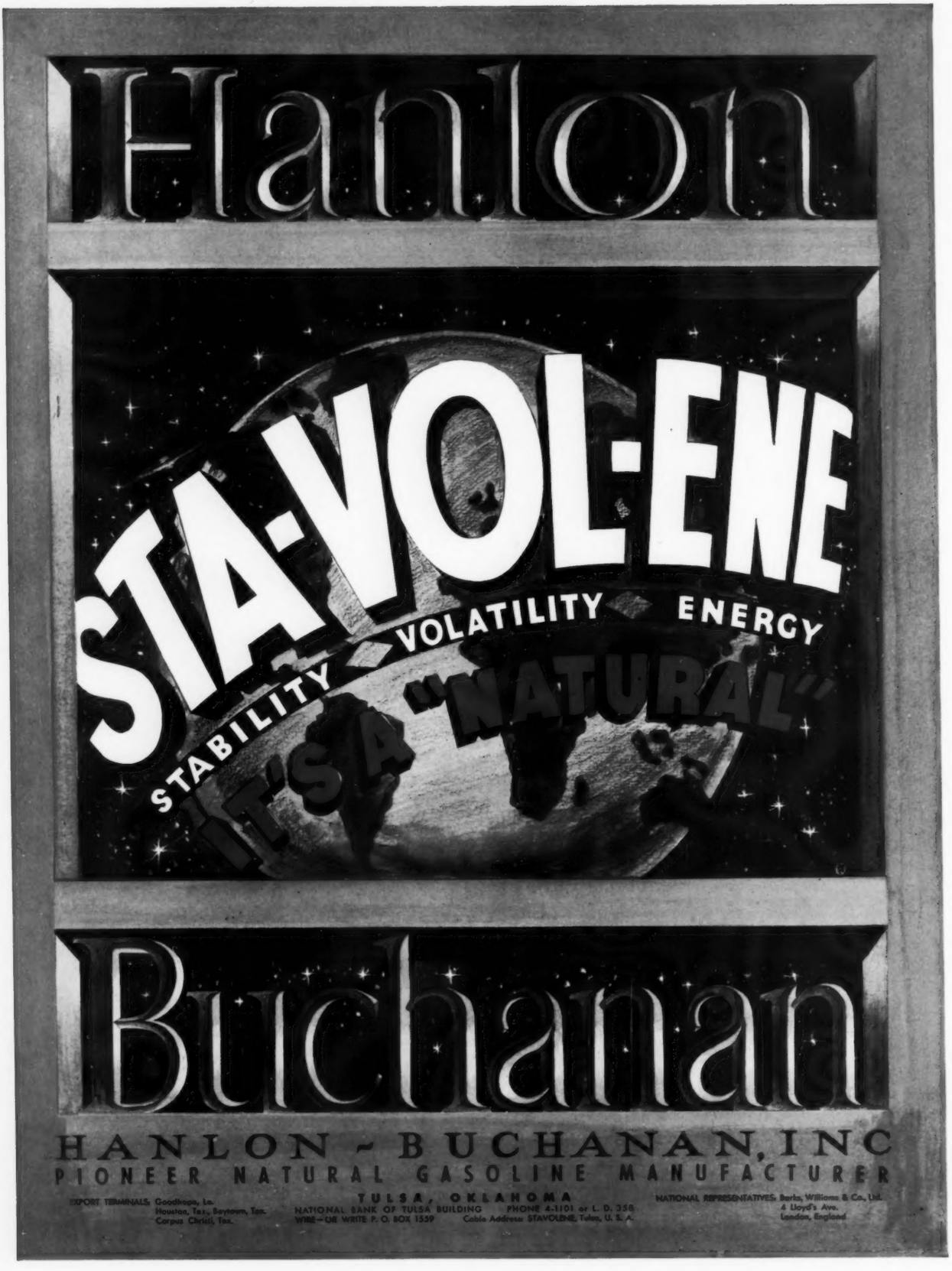
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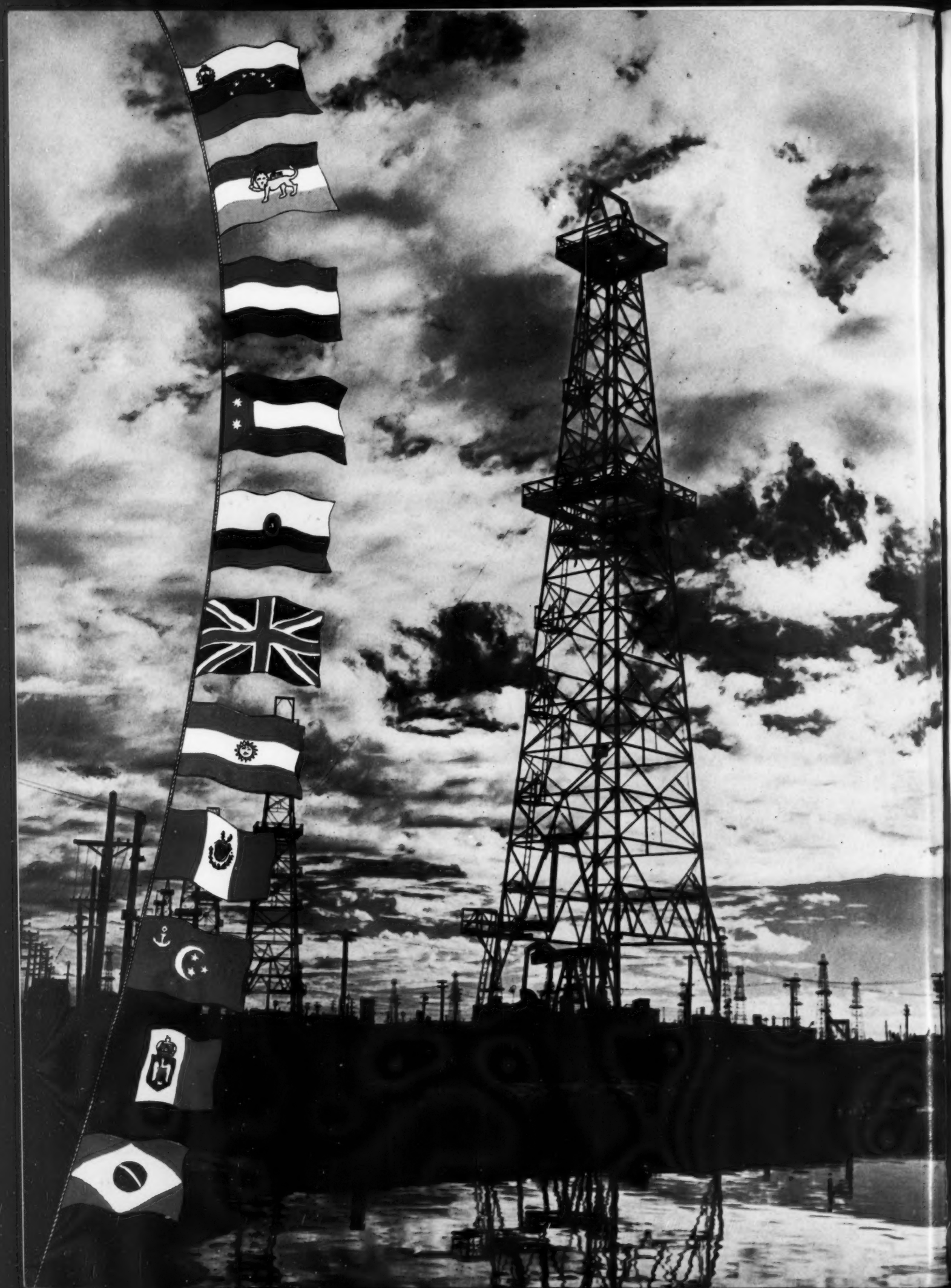


EDITORIAL

U. S. POLICY RETARDS DEVELOPMENT OF LATIN AMERICA

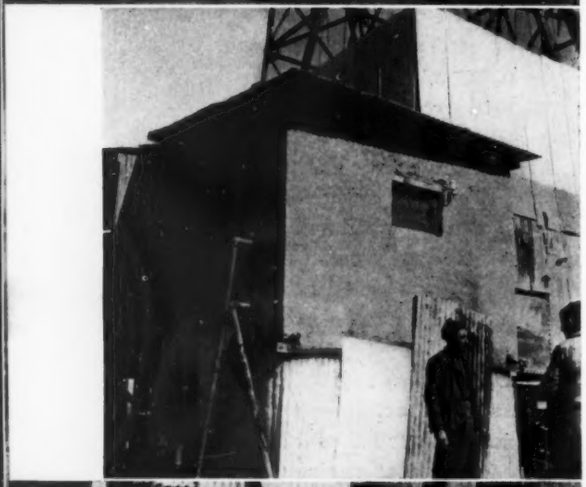
ONE of the cherished ambitions of President Roosevelt undoubtedly has been the building up during his administration of a better understanding and closer trade relations between the United States and Latin America. To that end he promulgated the Good Neighbor policy soon after his first election. He discarded precedent by going in person to visit South America. Under the zealous leadership of Secretary Hull the Department of State has devoted a great part of its time and energies to the tedious task of working out reciprocal trade agreements with countries that were willing to entertain such proposals. An examination of the treaties that have been concluded shows that while the purpose was to make them mutually advantageous the negotiators representing the United States have not hesitated to make sacrifices in respect to its own markets in order to create favorable conditions for the nations with whom they were dealing. In these and other ways the President and the members of his administration have demonstrated their desire to see the group of nations occupying the Western Hemisphere not only politically harmonious but commercially strong and prosperous.

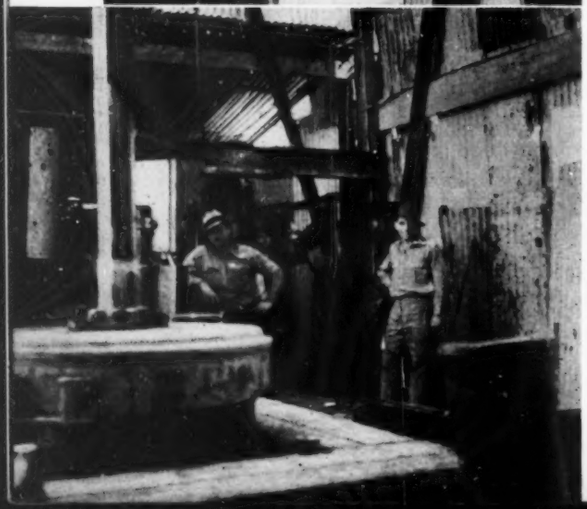
This is not mere altruism or undiluted philanthropy. Unquestionably Washington wants to increase the sale of United States products to other nations of the two Americas. To do this it stands ready to expand its purchases from them in order to establish a well balanced trade. It does not want to see its southern neighbors become commercial dependencies of nations with ideologies thoroughly inimical to the whole American system. It recognizes that as the countries of Latin America develop their resources and raise the standard of living of their own people they will become better able to resist the subtle encroachment of alien ideas and will provide better markets for the kind of products the United States has to offer.

Sound in principle as is this policy its practical application has been so inept as to threaten the defeat of both objectives. When the Mexican government, without a shadow of justification, seizes hundreds of millions which citizens of the United States have put into the development of Mexican oil, mines, railways and lands, and when it uses the products of these investments to cultivate trade with Germany and Italy, Washington protests but continues its subsidy to Mexican silver which almost alone keeps that country from economic chaos. When Bolivia coolly takes possession of properties on which an American oil company has spent $17,000,000 without a cent of return heads of the foreign department of the United States obligingly look the other way though these properties too are being turned over to the use of Germany. When other nations show signs of following the example thus set and private capital is thereby frightened away the attempt is made to fill the breach by the offer of hasty and ill-considered loans such as the one recently granted to Brazil. If confiscation becomes a recognized procedure what are the chances of such loans ever being repaid?

Failure to protect the lives and property of its citizens has a double barrelled effect injurious both to the United States and to the countries it is anxious to help. A government that supinely permits and acquiesces in the brutal violation of its rights earns contempt rather than respect. Its trade is bound to suffer from that very fact. Loans of $50,000,000 to Latin American countries do not and cannot accomplish the same result in the promotion of industry and trade as would the free investment of private capital any more than the payment of doles and benefits in the domestic field can substitute for the healthy circulation of wealth produced through the exercise of unfettered private enterprise.

(Continued on page 65)





NEAR EAST Discoveries Have Led to Vast Increase in Activities

In no other part of the world is the search for oil being pushed more vigorously or on a larger scale than in the countries around the eastern shores of the Mediterranean and in that part of Asia lying between the Caspian Sea and the Indian Ocean. Interest in the petroleum possibilities of this region has been keen since the development of the original D'Arcy concession in Iran and it has been intensified by the discoveries since made at Kirkuk, Bahrein and Dammam. At the present time rights of exploration or exploitation covering most of this area have been acquired by various groups. A number of important fields have been proved and scores of surveying parties are busily at work in the effort to establish other favorable locations for testing. Millions of dollars are being expended yearly and will continue to be spent for years to come in carrying on this work.

Among the operations in the Near East none outranks in importance those of the group of international companies which first collaborated in forming Iraq Petroleum Company, Ltd. This group, consisting of Royal Dutch-Shell, Anglo-Iranian, Jersey Standard, Socony-Vacuum and the Gulbenkian interests, has since obtained control of the B.O.D. Company, the capital of which is held by Mosul Oilfields, Ltd., and has formed the Basrah Petroleum Company, Ltd., and Petroleum Concessions, Ltd. The last named company in turn controls a number of subsidiaries organized to operate in the smaller countries and principalities of Asia Minor. Iraq Petroleum, B.O.D. and Basrah Petroleum, Ltd., between them, hold concessions covering the whole of Iraq.

The Kirkuk structure from which Iraq Petroleum Company draws the 30,000,000 bbl. yearly which represents the approximate capacity of its pipeline to the eastern shores of the Mediterranean is now a dozen years of age and may be looked upon as a settled field. Drilling conditions are uniform and drilling technique is simple and standardized. To date the company has drilled 70 wells and to maintain its established production finds it sufficient to keep one rotary rig in operation.

The chief items of a typical rig now in use are a steel derrick 122 ft. by 24 ft., horizontal twin cylinder engine 11 by 11 in., three-speed drawworks, slush pumps 14 by 17 by 18 in., a 27½ in. rotary and a battery of low pressure boilers. Good water is obtained from the Lesser Zab river. Water and fuel are taken from lines that run the length of the field.

Wells vary from 1,000 to 3,500 ft. in depth with an average of about 2,800 ft. It is usual to spud in with 20½ in. bits and to cement a very short string of 16 in. A.P.I. casing to the surface. After assembly of a blowout preventer, drilling is continued using 14⅞ in. rock and pilot fishtail bits. The section drilled contains a great variety of rock types, sandstones, siltstones, gypsum, anhydrite, salt and thin limestone, some of them rapidly alternating. Originally it was found necessary to make frequent round trips, but modern rock bits have to some extent overcome this. Identification of beds drilled is satisfactorily accomplished by examination of cuttings caught on vibrating screens, in conjunction with other methods developed locally, such as mud salinity determinations. At the top of the so-called Transition Zone, drilling is suspended and a string of 11¾ in. A.P.I. casing run and cemented up to the 16 in. snoe or the surface.

A 10½ in. hole is drilled below the 11¾ in. shoe. The rocks penetrated consist of predominating anhydrites with some marls and limestone, the latter becoming thicker towards the base and containing oil shows. Where the permeability of such limestone is high, a certain amount of mud ringing occurs, but otherwise no difficulty is experienced. A few cores may be taken in this section of the hole.

It is usual to identify the top of the main producing limestone before cementing an 8⅝ in. A.P.I. oil string. This is cemented up to the shoe of the 11¾ in. string.

Drilling-in is done with 7⅝ in. rock bits and, dependent on the information required, varying portions of the hole are cored. In the case of a well destined for production, it is usual to penetrate the limestone to a depth sufficient to afford the desired flow characteristics on test. If preliminary tests are not up to a recognized standard, drilling is carried deeper until the required test conditions are fulfilled. Wells drilled for observation purposes may be completed at depths permitting the subsequent regular observation of gas/oil and oil/water levels.

Top left: Drilling well K. 42, one of the recent completions at Kirkuk. The lower pictures taken by Allen Hicks of Hydril Co. show a unique dog house made of mud and straw and the derrick floor of a recent pressure completion job, both taken at Kirkuk.

The Kirkuk field affords an example of the highly productive type of limestone pay in which a remarkable degree of pressure equilibrium exists in the oil zone and in which the permeability of the oil bearing rock renders the close spacing of wells entirely unnecessary. The pressure to be encountered at any location may be calculated in advance of drilling—this pressure depending only on the depth at which oil is reached and the surface elevation. As a result the weight of circulating mud required to exert a pressure equal to that of the formation may be easily controlled. In recent years drilling-in has been accomplished with fuel oil or even crude oil circulation, using, in the latter case, an entirely closed circulation system and flush joint drill pipe.

It should be mentioned that master gates are placed immediately above casing flanges in the course of drilling and that wells are completed with 8⅝ in. casing, no tubing being necessary.

Photo by Allen Hicks, Hydril Co.

Kirkuk oil seepage with fortress in background.

The B.O.D. Company obtained its concession in April, 1932. The concession covers that part of Iraq which lies west of the Tigris river, and north of latitude 33 deg. This area formed part of the concession granted to the Turkish Petroleum Co. (which changed its name to Iraq Petroleum Company in 1929) in 1925, prior to the revision of that concession in March, 1931.

Drilling exploration has been in progress since the year 1927. In the first instance the Turkish Petroleum Company put down four wells. Subsequently, after the revision of that concession, the B.O.D. Company put down a large number of wells in various parts of the 43,000 square miles of territory concerned and at the present time an active drilling program is still being carried out in a number of widely separated districts.

The operations are carried on by Diesel driven rigs. The heavy type used includes a steel derrick 136 ft. by 26 ft., two five-cylinder Diesel engines, 200 h.p. each, 500 r.p.m., 8-speed drawworks, 2 slush pumps 7¼ by 14 in., power driven, and wire lines 1⅛ in.

The casing programs vary considerably according to the requirements of each area. Regular A.P.I. sizes are in general use. Recently, special internal and external flush joint casings have been introduced to allow of the setting of an extra string where this is required. Drill pipe has usually full-hole tool joints, although exterior flush drill pipe is now used for drilling-in and for pressure drilling.

One of the chief difficulties in drilling is the loss of circulation due to encountering low pressure porous formations. A considerable study of this problem has been made and numerous methods are in use to overcome the difficulties, such as the use of special materials, the cementing of fissured zones and the scientific control of mud flush.

In addition to the usual methods of subsurface investigation, such as examination of cores and cuttings, the Schlumberger device has been introduced to give assistance in the determination of the fluid content of strata, and this particular application of electrical survey methods is a subject of continual study.

The formations drilled are generally very hard and rock bits are in use from the shallowest depths.

The testing of formations for actual production capabilities is carried out by bailing and swabbing in the usual manner, and also by use of formation tester equipment, the latest types of which are used. During all drilling operations blow-out preventers are installed at the well head.

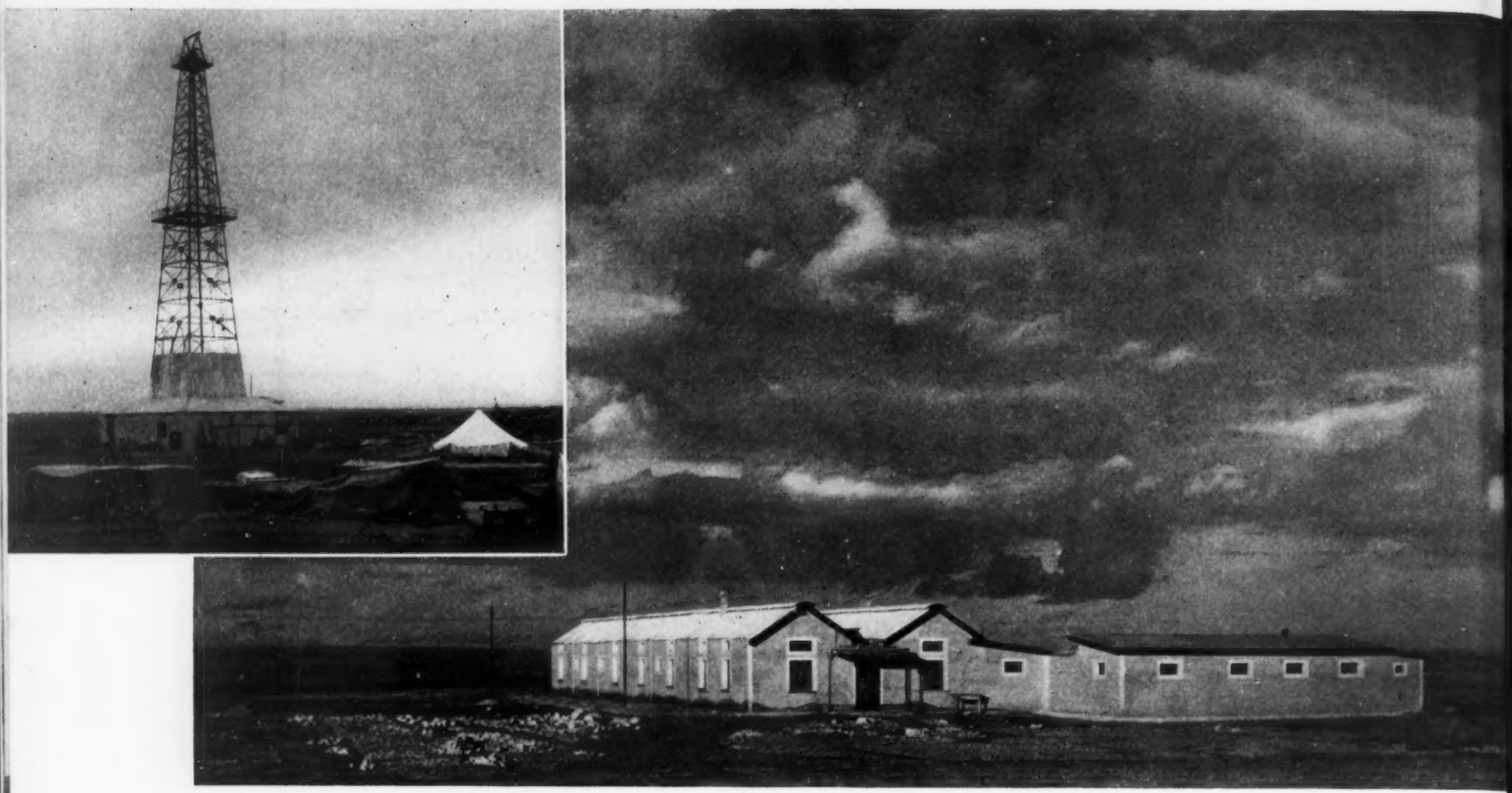
The transport across barren desert country of the large amount of material required for these drilling operations creates a considerable problem in itself. This is overcome by use of modern types of motor trucks. Tractors are used to a limited extent where they are found to be necessary. Aeroplanes are used for the transport of staff and urgent light material, and considerably reduce the difficulties of supervision. Landing grounds have been prepared at a great many of the out-stations and several good airports are available in the concession.

Water for drilling operations is obtained either from shallow service wells or from the Tigris or Euphrates rivers if they happen to be within reasonable distance of a location. The water from the service wells is apt to be gypseous; accordingly the river waters are preferred although they require the installation of a special type of floating pumping station, due to the relatively large rise and fall of the river levels. The fuel oil for the Diesel engines is transported to the locations by truck. Clay-pits have generally been found in the vicinity of the locations, and the clay has been transported to the well site and the mud mixed on the spot and chemically treated in pits and tanks where necessary. A supply of barytes is always held in readiness, either in the main stores or at the well site.

Basrah Petroleum Company's concession came into force November 30, 1938. It covers all parts of Iraq not included in the territories of the Iraq and B.O.D. companies except the small area in the eastern part of the country which formerly was part of Iran and is held by Anglo-Iranian Oil Company, Ltd. Geological and geophysical work is now in progress in Basrah Petro-

Cleaning drilling equipment outside the tool house at Kirkuk.

Photo by Allen Hicks, Hydril Co.



Doubayat drilling location and Derro camp, headquarters for exploration in the Syrian desert for Petroleum Concessions, Ltd.

leum Company's holdings. It will be some time before test drilling is started.

Of the several subsidiaries of Petroleum Concessions, Ltd., the two that have reached the stage of active drilling are Petroleum Concessions (Syria and Lebanon) Ltd., and Petroleum Development Qatar), Ltd. The former began test drilling in Syria in 1937 in connection with the survey carried on at that time. The first deep test well was spudded in on February 4, 1939, and two such tests are now in progress. Headquarters for direction and the handling of supplies in connection with this work are at Deir-ez-Zor on the Euphrates.

Conditions attending the transport of drilling material in this area are practically the same as those encountered in the building of the Iraq pipeline. Roads are but tracks through sand and among boulders. Where these are fairly well cleared they can be negotiated by two-wheel drive trucks. Where the going is heavier four-wheel and six-wheel drives are brought into play and in the worst sections Caterpillars are relied upon.

The drilling outfits employed are Diesel driven and capable of going to depths of 9,000 to 10,000 ft. The derricks are 136 ft. in height with 26 ft. base and 9 ft. substructures and are rated to take a pull of 150 tons. The Diesel engines, each of 200 B.H.P. at 550 r.p.m., are interconnected to drive drawworks, rotary table and two slush pumps, each 7¼ by 16 in. capacity. The drawworks have eight speeds for a rope tension of 15 tons at the drum. The rotary table has a 27½ in. opening fitted with ordinary cast steel bushings. As greater depth is reached an auxiliary hoist with independent Diesel drive will be added as well as hydraulic brakes.

The casing and drill pipe sizes are: 16 in. A.P.I. 65 lbs. per foot, Grade C; 11¾ in. A.P.I. 47 lbs. per foot Grade C; 8⅝ in. A.P.I. 36 lbs. per foot Grade D; 6⅝ in. outside flush 26 lbs. per foot Grade D. Drill pipe and tool joints are in 30-ft. lengths with modern designed threads. A.P.I. tapered tool joints are of the following sizes: 6⅝ in., 26 lb., 4½ in., 16 lb. and 3½ in., 12 lb., all with full hole tool joints. Cellar control is provided by blowout preventers of the ram type, allowing collars to be passed under pressure.

While it is still too early to make extensive comment on drilling conditions it can be stated that the drillers have found fairly hard going through alternating hard shales, anhydrites and limestones of varying thickness for which rock bits are generally necessary. Cores are taken where bit cuttings will not give sufficient information of the formations passed through.

A concession over the principality of Qatar, a peninsula on the western side of the Gulf of Iran, was obtained in 1935 by Petroleum Development (Qatar), Ltd. After two seasons' geological work, a site was selected for the first test boring on the west side of the peninsula, about two miles from the sea.

The usual preliminaries of building a jetty for unloading plant, making a road from the jetty to the location and laying water line for transporting fresh water, which has to be imported, were completed early in 1938 and the camp was made ready for habitation in August. The buildings comprise sleeping and living quarters for 15 Europeans and some 120 natives. These buildings are made of native stone and gatch (burned gypsum or plaster of Paris) and were erected by local contractors. The camp is equipped with electric light and power, ice plant, Marconi wireless with 1,000 miles range, a small first-aid hospital, a hard tennis court and individual air conditioning and cooling units for the sleeping quarters.

The drilling rig is a modern Diesel powered outfit capable of going to a depth of 7,000 ft. It consists of a galvanized 122 by 24 ft. derrick with 5½ ft. opening, capacity 150 tons, steel substructure 6 ft. high. There is an extension to accommodate the rig but the pumps are set on the ground. The draw-works have eight speeds, 18 in. grooved drum and all up-to-date accessories with the exception of hydraulic brake which may be added later. It is driven by two 166 net B.H.P. Diesel engines equipped with countershaft to drive by chain one 6¾ by 14½ in. slush pump. In addition a second Diesel driven 6¾ by 14½ in. pump, mounted on a short skid, is situated some distance from the rig as a precaution.

The crown block contains five 36 in. sheaves with roller bearings. The travelling block is 36 in. and the hook has a capacity of 150 tons. The rotary table has a 20½ in. opening with roller bushings, one for 6 in., one for 4½ in. and one for 3½ in. kelly.

Drilling bits and reamers used, with the exception of a few drag bits, are all of roller rock type, including some hard-rock core barrels.

The latest type flow testers with pressure bomb for graphically recording pressure differential of flows are included in the outfit.

In spite of the great handicap of being unable to maintain circulation, good progress was made in drilling the first thousand feet, bit cuttings being carried away into fairly large crevices in the higher limestone series.

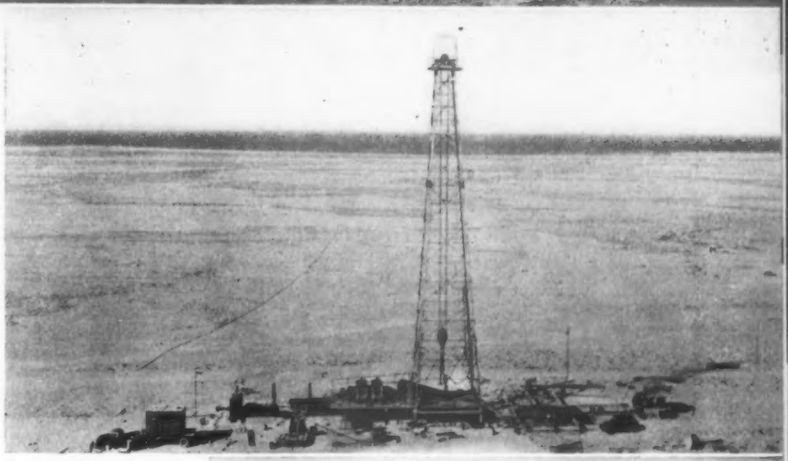
The first 16 in. string was set at about 1,000 ft. in impervious marl, after which circulation was maintained. Drilling is now proceeding.

In Iran the two principal fields of Masjid-i-Sulaiman and Haft Kel, which have been producing for many years are now well stabilized with an output of 10,000,000 metric tons annually. In spite of the age of the former field the fall in dome pressure shows no appreciable variation from the low rate of 0.3 lb. per square inch per million tons net production. Drilling in this field is limited to deepening old wells and drilling such new ones as are needed for maintenance of production and general reservoir control. In the past few years the rate of offtake has been reduced, in view partly of depletion of the oil column, but production at Masjid-i-Sulaiman is expected to be maintained at about the present rate of 3,000,000 tons yearly.

Production from the Haft Kel field has steadily increased since it was opened in 1929 and is now over 6,000,000 tons per year. An exploratory well to test deeper formations in this field has proved the existence of productive conditions in the Eocene which underlies the Asmari limestone which is the main producing horizon. Drilling to the northwest of Haft Kel, in the White Oil Springs area, has revealed the existence of a separate structure with important productive possibilities. One well, with a satisfactory production rate, has been completed.

Within the past two years a new field that promises to rank equal with these older ones has been developed at Gach Seran (Gach-i-Qaraghuli). Two wells have been completed and the work of delimiting the field is going steadily forward. The extent of the field cannot be forecast accurately until edge water is located but the zone thus far proved is approximately twenty miles along the strike and five miles wide in its broadest part. The characteristic feature of drilling in this field is that it must be carried on against high pressures. Heavy equipment is therefore needed. To utilize the output of the field it will be necessary to construct a pipeline to the coast and survey work is now proceeding to locate the route of this line.

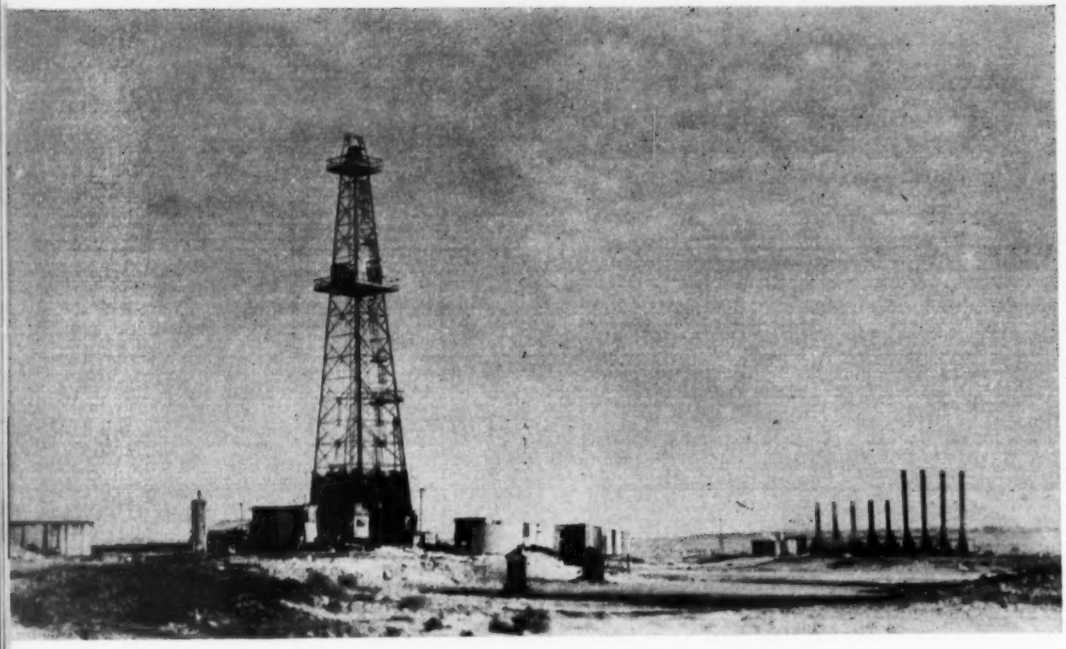
Above and to the right are shown scenes from the Qatar peninsula. Bird's eye view of the camp, and test drilling. Below, unpacking truck and highway trailers at Zekrit pier in heavy weather.



Exploratory drilling is being carried on by Anglo-Iranian at several places within its concession in addition to the fields mentioned. At Agha Jari, some 55 miles southeast of Haft Kel and 70 miles northwest of Gach Seran, a deep test has revealed the existence of productive conditions but no further details have been given out by the company. At Pazanun, southeast of Agha Jari, two wells have encountered gas at considerable depth and the prospect of finding oil in this district is considered favorable. On the Lali structure, northwest of Masjid-i-Sulaiman, a bore penetrating 1200 ft. of Asmari has given small production and several other wells are being drilled to test the potentialities of this area.

At the present time Anglo-Iranian is conducting a thorough investigation into pressure drilling and mud flush problems for the purpose of dealing effectively with the great depths and high pressures already encountered and certain to be met in future developments.

On the shore of the Gulf of Iran not far south of the Iraq border in the Sultanate of Kuwait a one string drilling program is maintained by the Kuwait Oil Company. This company is a joint venture of the Gulf Oil Corporation and the Anglo-Iranian Oil Company. The first well drilled, Bahra No. 1 proved to be a dry hole so equipment was moved to a new location where Burgan No. 1 was successfully completed in 1938. Equipment was then moved two miles east of this location and Burgan No. 2 was completed, confirming the indications found in Burgan No. 1. At present the company is engaged in drilling Burgan No. 3 to the east of the last location and it is expected that this well will be completed shortly. For the next several months only one string of tools will be used but late this year or early next a second complete outfit will be shipped to Kuwait to speed up the drilling campaign.



Discovery of oil on Bahrein Island in 1932 by Bahrein Petroleum Co., Ltd., now jointly owned by Standard Oil Company of California and The Texas Corporation, greatly broadened the possibilities of petroleum production in the Near East and vastly stimulated interest in the exploration of that whole region. The discovery well, first to find production on the western side of the Gulf of Iran, came in at 2,008 ft. Further drilling disclosed a field of major size, geologically an elongated anticline extending from northeast to southwest. A large number of wells drilled to the 2,250 ft. level came in flowing from Cretaceous limestone and sandstone with an average output of about 7,000 bbl. per day. Results of this early drilling were so impressive that the company erected a refinery at Bahrein which is now being enlarged to a capacity of 30,000 bbl. daily. The products of this refinery are marketed throughout the territories east of Suez by California Texas Oil Company.

In investigating the further possibilities of its field the Bahrein Company tested deeper formations and at the 4,700 ft. level it found production which not only was greater in volume than that of the more shallow wells but yielded a higher grade of oil. In reality there are four producing horizons between the surface and the 4,700 ft. level but the most important of these is the latter.

At the present time the Bahrein Company has 56 wells producing from the second pay, that is from around 2,250 ft. Two wells have been completed to the fourth pay, or 4,700 ft., and the company has launched a program of working over its earlier wells and carrying these to the lower depth. Two wells are now drilling and plans have been laid for the sinking of others. Five rigs are kept in operation.

To the end of 1938 the cumulative production of Bahrein was roundly 23,000,000 bbl. and its present rate of output is above 20,000 bbl. daily. Operating on a greatly restricted basis it already has placed Bahrein among the first dozen of the world's producing countries and its full potentialities are only now beginning to be developed.

Following its success at Bahrein the Standard Oil Company of California pro-

Above, Bahrein Petroleum Company (California Standard and The Texas Company) deep test No. 52.

Right, somastic machine treating a short pipeline in Eastern Saudi Arabia. The line was built to carry oil from the Dammam field developed by California Arabian Standard to the Gulf of Iran.

Another view of work on the 10 in. Dammam to Gulf of Iran line: the work — unique to this part of the world—is preparing a camel crossing over the exposed line.

Tractor with shoe extensions preparing the pipeline right of way in Eastern Saudi Arabia.

Left above, native workmen in Saudi Arabia riveting the top angle on Dammam tank No. 9. Right above, opening the loading valve at Al Khobar wharf in the Gulf of Iran as Dammam crude began to flow toward world markets.

ceeded with exploration of the concession it had acquired from King Ibn Sa'ud in 1933, covering approximately 165,000 square miles in Eastern Saudi Arabia. This work has been carried on by the California Arabian Standard Oil Company, now jointly owned by Standard of California and The Texas Corporation. The first drilling was done at Dammam, about 50 miles from Bahrein, and in 1936 oil was found at 2,175 ft. in this structure. Several other wells were bored to approximately the same depth but yields were small and indications pointed to their early exhaustion. In 1938 exploration was carried to deeper horizons and at the 4,200 ft. level prolific production was obtained from what is now known as the Arab zone.

Following this discovery a comprehensive plan for deepening the wells previously drilled was adopted. At the end of May four of these wells had been carried to the Arab zone, one other had completed drilling and was in process of testing, five others were in various stages of drilling and three others were being prepared for the drill. There remains no doubt that Dammam is a field of first rate importance. At the present time production is being held to about 8,000 bbl. daily. The company has constructed a 10-in. pipeline 40 miles in length from the field to deep water at Ras Tanura where a shipping terminal has been erected. This terminal was completed at the end of April and the first shipment of oil to a foreign port was made on May 1, 1939. A completely modern camp has been built at Dammam with air conditioned houses for employes, power plant, machine shops and all other facilities, attesting the permanent nature of the field.

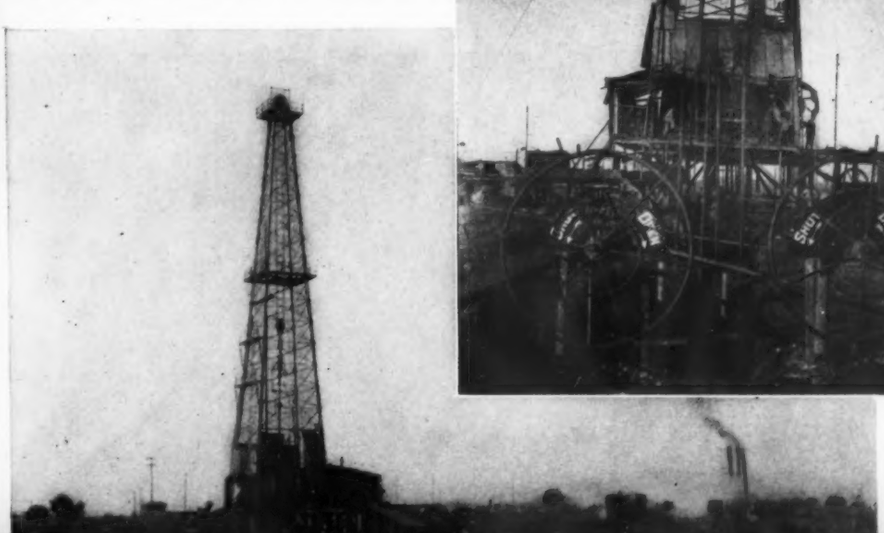
While the energies of the company have been occupied thus far mainly with the development of the Dammam field geophysical exploration has been going on in other areas. At Abu Hadriya, north of Dammam, a wildcat is being drilled and sites for other test wells have been located. Dammam alone is sufficient to give Saudi Arabia a recognized position among oil producing countries but there are alluring possibilities that the California Arabian concession, which is nearly as large in area as the state of California itself, ultimately will be found to contain not one but several important fields.

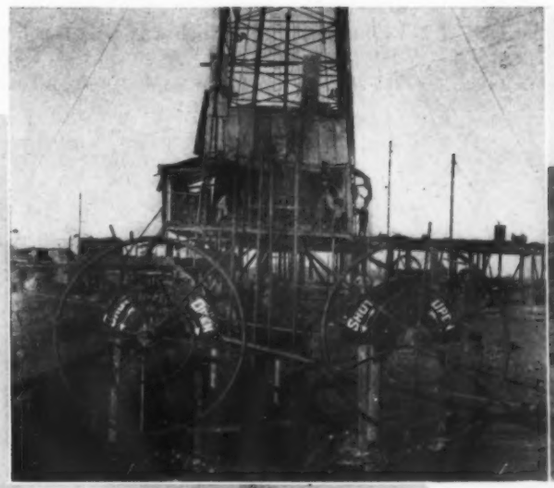
At various other places on the Arabian peninsula, as in Palestine and along the Trucial Coast, programs of exploration have been formed or are under way but these have not yet reached the drilling stage. Within the next few years, however, every part of this great territory will be

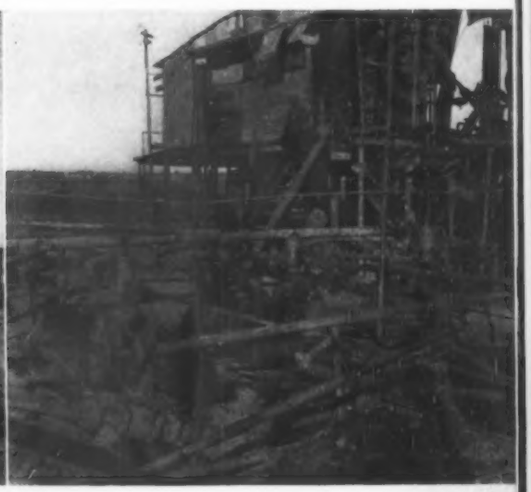
Photos by Allen Hicks of Hydril Co.

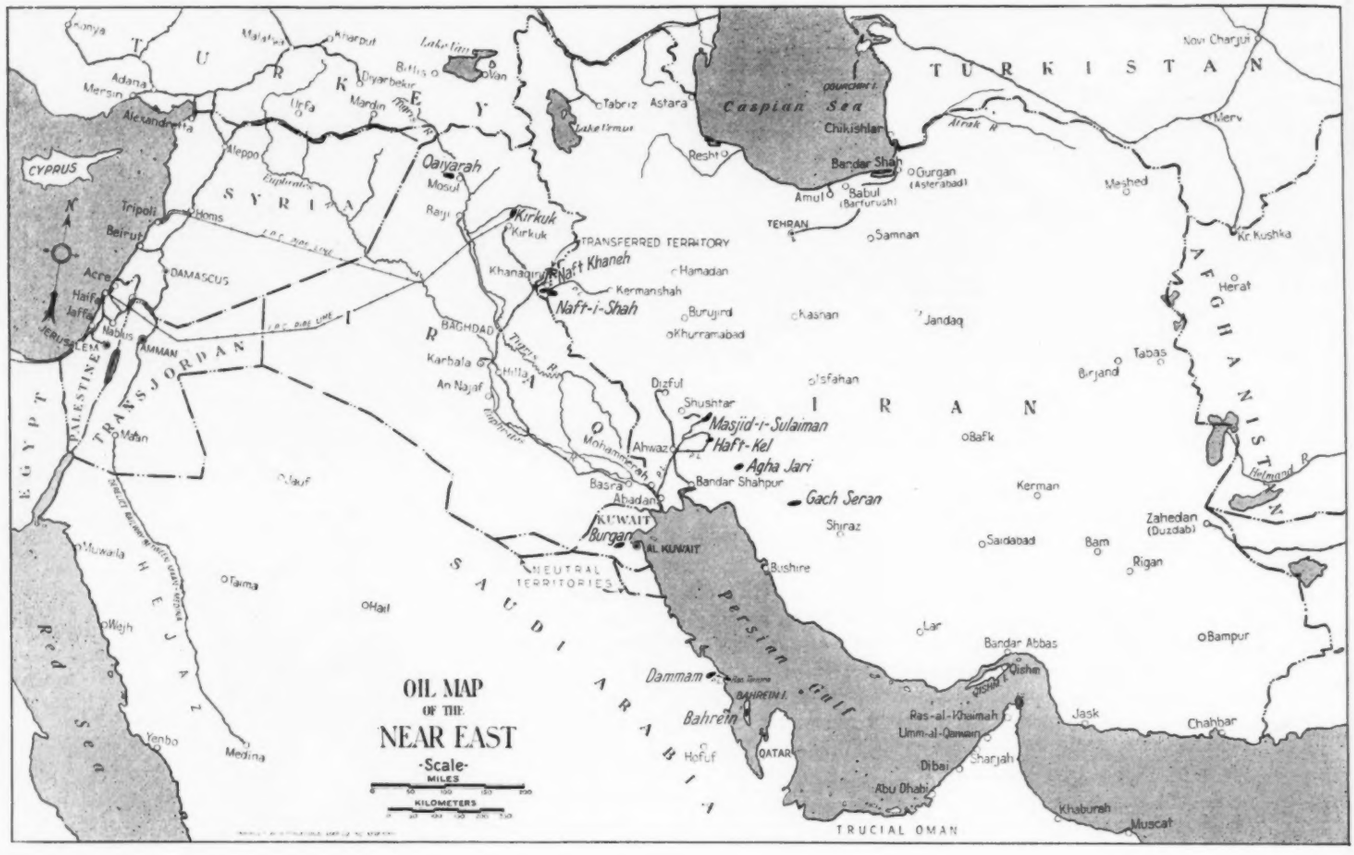
Handling freight at sundown on the Ras Tanura pier serving California Arabian Standard Oil Company's development and exploration work in Saudi Arabia.

General rig views in the new Dhulian field of Attock Oil Co. in Upper Punjab District, India. Note the works used to operate blowout preventor. Pressure drilling reached a high stage of development in India.









carefully examined and tested for petroleum. In the light of discoveries already made it seems certain to hold its place as one of the world's great producing areas.

Although in a geographical sense India belongs to the Middle East rather than the Near East it may not be out of place here to refer to the fact that one of the greatest programs of geophysical exploration ever undertaken is being carried out in that country.

Developments of Attock Oil Co., Ltd. at its new Dhulian field continue to be satisfactory and four wells have been drilled into the oil formation at about 7,700 ft.—the last had an initial yield of some 3,000 bbl. per day. The present program aims at drilling wells to just above the oil horizon until completion of the new refinery and erection of storage. All wells have been located at wide spacing to ascertain the productive limits of the field. Little producing and no drilling are being carried on at the older field of Khaur. A deep test is being drilled at Jhatla 30 miles south of Khaur; now at some 4,000 ft., it may exceed 7,000 ft. At Ganda Kas, a similar distance north-west of Khaur, another wildcat is being drilled which should ascertain the oil-producing possibilities at about 2,000 ft.

During the past year or two the Burmah Oil Company, Ltd., which was a pioneer in the use of geophysical methods in India (having carried out extensive torsion balance surveys there as long ago as 1923), has undertaken extensive geophysical exploratory work in Western India and in Assam. The work is being tackled in a very thorough manner, no less than 14 separate geophysical parties being now in the field and both gravity and seismic methods being employed.

The gravity instruments in use, in addition to the torsion balance, are the Holweck, Thyssen and Ising instruments, all of which are understood to be working satisfactorily. The seismic work is being carried out by the Petty Company.

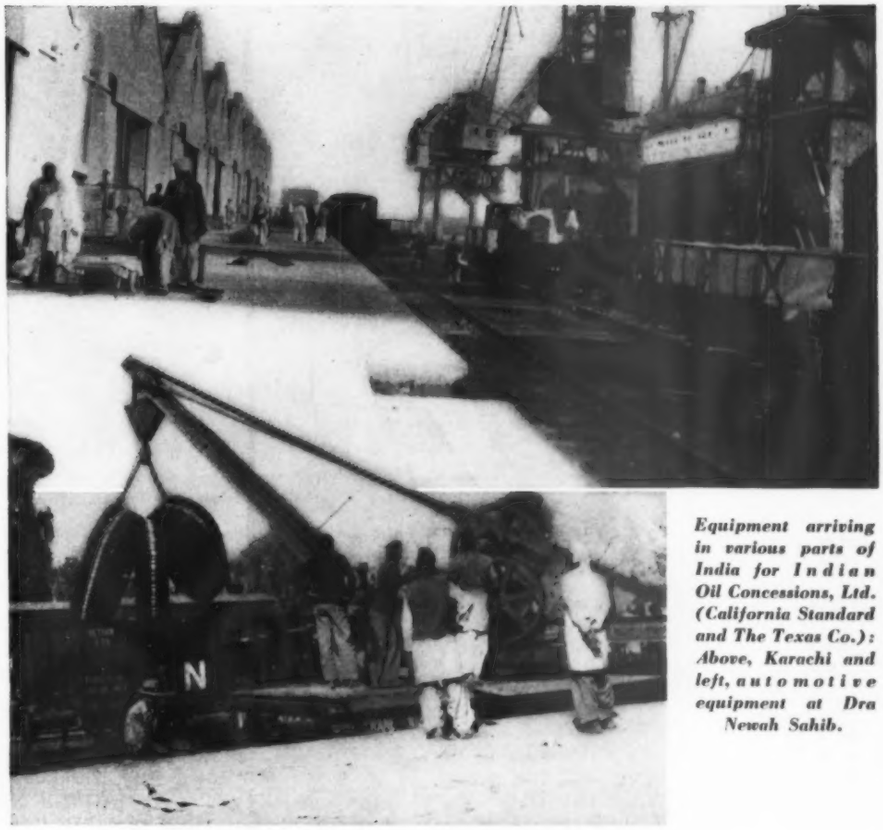
Two views of Petty seismograph crews in India: left, the shooting truck and part of the crew on the elephant; right, Holongopar Reserved Forest in India.

The alluvial plain of the Indus under examination in Western India covers the territories of several provinces and Indian states, the largest area in any one province or state being that which lies in the Punjab.

In addition to this geophysical exploration intensive re-examination of exposed structures is being carried out, both on the ground and by means of aerial photography, and it is understood that preparations have already begun for test drilling in Sind, Baluchistan and Tripura, the latter state in Eastern India bordering Assam.

The company's headquarters for the work in Western India are at Karachi. The work is spread over such a big area that widely differing conditions are encountered as regards temperature, rainfall, desert, jungle, etc., but so far as possible personnel are moved from one region to another in such a way as to provide continuous employment throughout the year.

Another company now actively engaged in geophysical exploration in India is Indian Oil Concessions, Ltd. Standard Oil Company of California and The Texas Corporation are associated with British financial interests in this company which was organized in 1938 and acquired a five year prospecting license covering the entire state of Bahawalpur in the Punjab. This concession covers 16,434 sq. mi. A group of geologists and a geophysical party were sent into this area at the beginning of the year and seismographic work is now in progress. Negotiations are understood to be going on for other acreage in the valley of the Indus and in Baluchistan where attractive possibilities are held to exist.



Equipment arriving in various parts of India for Indian Oil Concessions, Ltd. (California Standard and The Texas Co.): Above, Karachi and left, automotive equipment at Dra Newah Sahib.

Geophysical work in India for Indian Oil Concessions, Ltd.; left, loading the first hole and above, the shot; at Bahawalpur.

BRITISH OIL IMPORTS

WIDE CHANGES in the shipping and refining policy of the big groups operating in Britain are indicated by United Kingdom petroleum import statistics. Receipts for January to April were below those for the same period of last year.

British Oil Imports by Products (Barrels)

	April 1939	Jan.-Apr. 1939	Jan.-Apr. 1938
Kerosene	674,000	2,525,000	2,286,000
Motor spirit	4,050,000	14,515,000	13,554,000
Lubricating oil	221,000	1,052,000	1,142,000
Gas oil	471,000	1,989,000	1,605,000
Fuel oil	1,188,000	5,575,000	7,656,000
Other sorts	14,000	159,000	192,000
Refined products	6,618,000	25,815,000	26,435,000
Crude oil	1,345,000	5,437,000	5,072,000
Total imports	7,963,000	31,252,000	31,507,000

The Anglo-Egyptian Oilfields Ltd. (Royal Dutch-Shell) development at Ras Gharib has inaugurated a new era for Egypt's oil industry, and halted her declining production.

RAS GHARIB DISCOVERY Brings Rush of Prospecting Activity to Egypt

WHILE oil has been produced in Egypt for upward of a quarter century a great impetus to further exploration was given in 1937 by the action of the Egyptian government in changing and liberalizing its mining regulations. Following this revision leading international interests acquired exploration permits and surveys are now being conducted covering much of the area from the Sinai peninsular to beyond the western edge of the Nile delta. As a result of the exploratory work already done one important new field has been developed and the next two or three years will see a large amount of test drilling in all these districts.

Prior to 1937 the only company active in Egypt was Anglo-Egyptian Oilfields, Ltd., a member of the Royal Dutch-Shell group in which Anglo-Iranian Oil Co., Ltd., also holds an interest. This company began its operations in 1912 and developed the Gemsah field situated about 150 miles south of Suez on the Egyptian shore of the Gulf of Suez. Twenty-three wells were drilled at Gemsah and for some years it was the only source of Egyptian production but its output gradually declined and since 1927 it has been inoperative.

In the meantime Anglo-Egyptian discovered the Hurghada field, about 50 miles south of Gemsah and established its headquarters there. Hurghada production rose steadily to a peak of 280,400 tons in 1931. Since then it has as steadily declined and in 1938 was 150,700 tons. The oil is a heavy asphaltic base crude of about 25 deg. Beaumé and is produced as a stable emulsion with salt water. The breaking down of this emulsion was one of the big problems which the Anglo-Egyptian had to solve. After extensive experiments an electrical dehydration plant was installed which has been giving efficient results for several years.

Hurghada is a water drive field and in recent years the salt water content of the crude has increased rapidly. In 1938 no less than 1,116,000 tons of liquid were brought to the surface for a net oil production of 150,700 tons. Production is at present obtained from 76 wells, all pumping, and most of these are produced by central pumping powers operating jerk lines.

The cable tool drilling system is employed at Hurghada mainly owing to the difficulty in the past of producing a satisfactory mudflush with salt water. There is no fresh water and all water for domestic and other purposes has to be transported from Suez by tanker. There is deep water for ocean going tankers at the end of the company's jetty and the crude is shipped to Suez refinery for treatment.

In view of the declining production at Hurghada it was of great importance to the Anglo-Egyptian to discover an alternative source of indigenous production and when the Egyptian Government issued the new petroleum mining regulations previously referred to, the company immediately applied for exploration permits over the parts of Egypt and Sinai which were considered to be the most promising.

An extensive geological and gravimetric survey was undertaken and a promising structure at Ras Gharib, lying about half way between Suez and Hurghada, was selected for the first deep test. This well was spudded in on December 1, 1937, and was completed in April, 1938, at 2,560 ft., with a production of 150 tons per day. A Diesel rotary outfit was used and a satisfactory mud flush was made, using clay from a deposit near the well and salt water. The erection of tankage and loading facilities was pushed ahead rapidly and the first shipment of Ras Gharib crude was made on August 18, 1938.

It was necessary to launch an eight inch submarine pipeline to a sufficient depth of water for the loading of tankers and a second line is to be launched in the near future.

A total of seven wells have now been completed and the production in 1938 was about 80,000 tons. The oil is very similar in character to the Hurghada crude and it is all shipped to Suez refinery for treatment. As the oil is produced free of water there are no emulsion difficulties.

Exploration work on a large scale in other areas is being continued and in the future test wells will be drilled on a structure about eight miles inland from Ras Gharib and also in Sinai on the opposite side of the Gulf of Suez.

Other groups that obtained exploration permits through subsidiaries in 1937 and 1938 were Standard Oil Company of New Jersey, Socony-Vacuum Oil Co., Inc., Anglo-Iranian Oil Co., Ltd., Standard Oil Company of California and The Texas Corporation. The two last named have pooled their interests under the name of South Mediterranean Oilfields, Ltd., with exploration permits covering roundly 6,000,000 acres. Geological and geophysical prospecting is now being carried on by all these groups. Aside from Anglo Egyptian the only company that has reached the stage of test drilling is Socony-Vacuum

though some of the others have selected locations for such tests. To date two prospecting licenses have been granted to Socony-Vacuum. The first of these is at Dishet el Dhaba, some 250 miles south of Suez on the coast of the Red Sea and a few miles south of the Hurghada field. A well drilled there in 1938 was abandoned after encountering granite at 2,000 ft. Drilling equipment was then moved to Giftun-Saghir island about 15 miles northeast of the first location. Drilling of this well was temporarily halted at 2,970 ft. by a fishing job. A third location selected by this company is a short distance northwest of Hurghada on a torsion balance structure. This probably will be the next to be tested.

Socony-Vacuum has drilled the two wells thus far put down with a medium duty Diesel driven rotary rig. A portable rig, truck-mounted and Diesel powered is now being added. From preparations made it appears that the company contemplates a considerably increased drilling program.

OTHER AFRICA

From time to time efforts have been made to locate oil in many parts of Africa but to date Egypt is the only country that has yielded returns at all substantial. Following up its small discoveries in Morocco a few years ago the French government has carried on an extended search in its African possessions, in some instances acting directly and in others extending encouragement to private companies. A special commission acting for Cie. Francaise des Petroles and the Office Nacional des Combustibles Liquides is now engaged in a study of conditions in French Equatorial Africa. A recent report stated that surface indications of oil had long been observed in the coastal regions between Pointe Noir and Port Gentil but the prospecting party had not been able as yet to obtain definite results. Three wells had been driven to 1,315 ft., 2,300 ft. and 2,960 ft. Indications are that if oil exists in commercial quantities it will be found at greater depths which can be reached only by use of a rotary drilling rig.

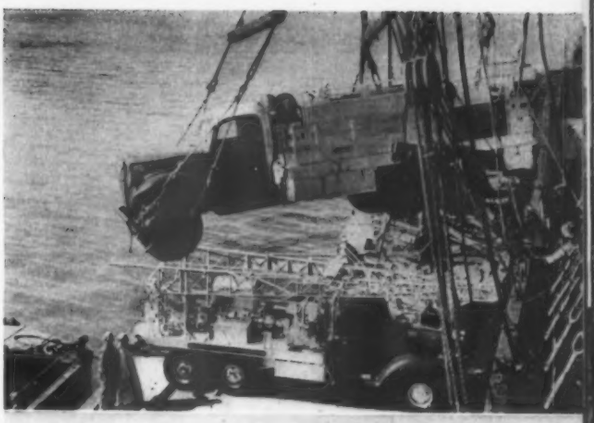
By a decree of December 31, 1938, the Tunisian government was empowered to take up interests in mining and research. One of the first steps being taken is an investigation of possible oil deposits in the district of Biserta. In Madagascar, another French possession, an exploration permit was issued a year or two ago to a company organized for the exploitation of oil deposits, but apparently its activities have not proceeded far.

In Nigeria which is known to have extensive bituminous deposits and where a previous attempt to locate oil was made without success Shell and Anglo-Iranian are now making another survey and drilling a test well which has not yet proceeded far enough to give any indication of results.

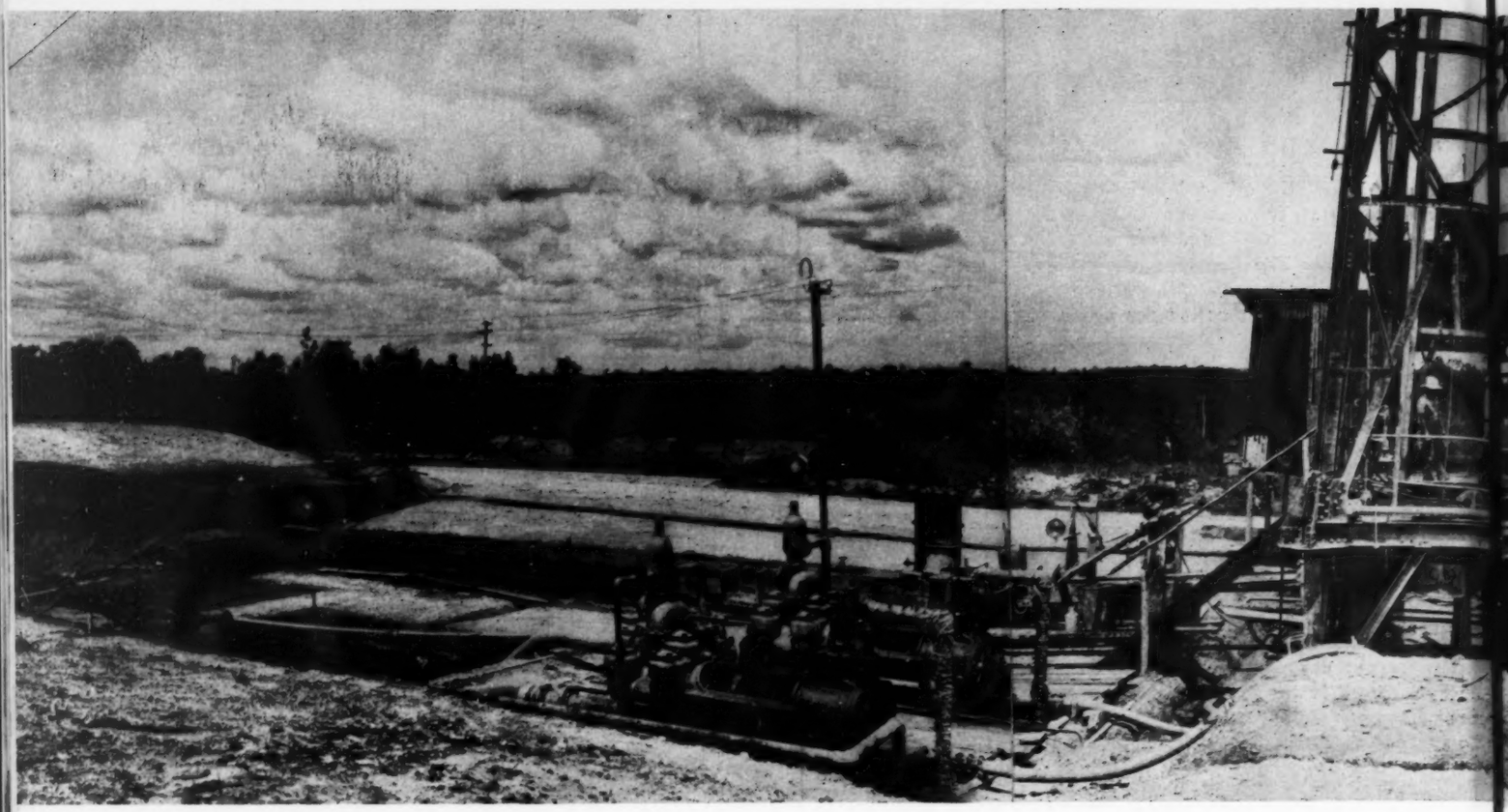
In Uganda, African and European Investment Co. Ltd., which holds a concession covering 1,384 square miles adjoining Lake Albert, started preliminary geological borings in December 1938. The company is operating under the tenchical guidance of Anglo-Iranian. A deep test now drilling at Waki Dome near Butiaba had reached 3,500 ft. several weeks ago. Further south, at Kibero, the company is preparing shortly to put down a series of borings with the prospecting drill.

On the other side of Lake Albert, in the Belgian Congo, further work is being carried out by Syndicate Petroleum Congo Belge, which was formed by Robert Hallet, prominent banker and plantation official of Brussels, to operate his concession along the lake shore. The Syndicate acquired the results of a surface geological survey carried out by the Kilo Moto Mines, at a cost of 1,000,000 Belgian francs and the Gety area has been selected for further testing by the drill. Several shallow holes are to be sunk with the equipment recently acquired from New York, this being a rig capable of reaching 3,200 ft. Should results indicate the desirability of deeper drilling, suitable equipment will be employed.

One European power that is keenly interested in the possibility of petroleum discoveries in Africa is Italy. For some time the government has been conducting geological studies in Ethiopia and in Italian Somaliland and there have been reports of projected exploration in Libya. None of this work, so far as reported, has resulted as yet in uncovering indications sufficiently favorable to justify drilling, but the search is continuing. This work is referred to on pages 66-69 of this issue.



The California-Texas group's subsidiary, South Mediterranean Oilfields Ltd., is actively exploring Egypt for oil—Top to bottom: lightering seismic equipment at Suez; moving torsion balance by camel when the going is too difficult by car; surveying sand dunes east of the Suez Canal, and sand dune crests in the western desert.



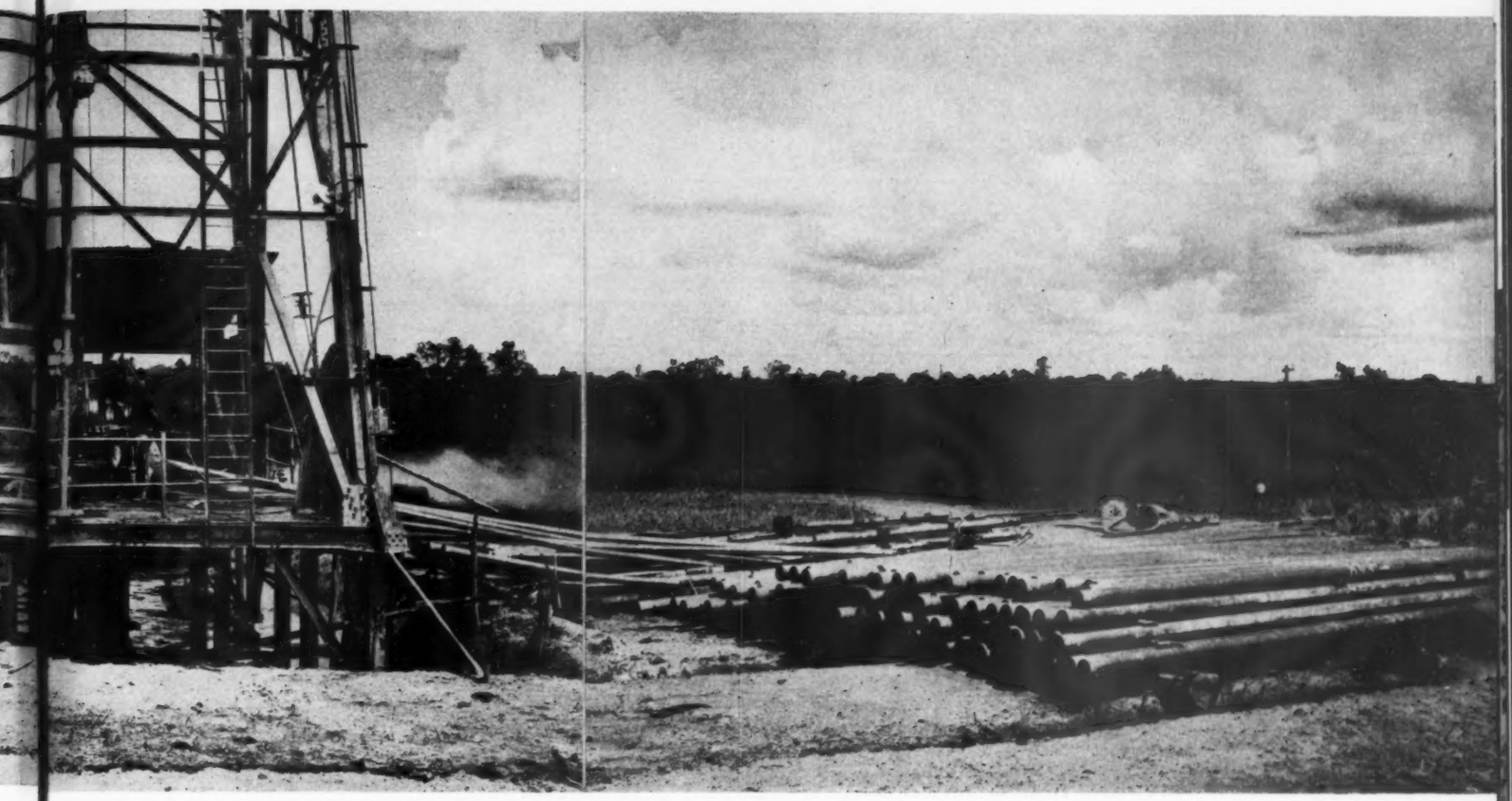
Modern drilling by Bataafsche Petroleum Mij. (Shell) in Netherland India where the tendency is to use the most efficient drilling equipment.

Petroleum Search Broadened in the FAR EAST

To UNDERSTAND the activities of the petroleum industry in Netherlands East India it is well to visualize the setting in which they take place. They are spread over an arc of tropical islands lying between the Pacific and Indian oceans, larger in extent than the United States. Total area is more than two and one quarter times that of Texas and nearly three and one half times that of France. The archipelago includes some of the largest islands in the world. It lies along one of the earth's major expansion joints and main lines of volcanic safety valves. Its western end abuts and is part of the continental shelf of Southeastern Asia. Its central reaches, occupied by the Lesser Sunda Islands, are separated by oceanic deeps and its eastern end lies on the continental shelf of Australia. It is therefore to be expected that the geology is greatly diversified and in many places highly complicated. Some islands, like Sumatra and Java, are long geanticlines, others like Celebes and Borneo form peculiar radiating or knotlike structural units. A great variety of Tertiary sediments occur, deposited in basins which differ widely in character and extent. Extensive deposition of continental and fresh water sediments in recent geological time has concealed the structure of the underlying strata over large parts of the areas of interest.

This great region is being actively developed and explored by three companies: The Nederlandsche Koloniale Petroleum Maatschappij, The Bataafsche Petroleum Maatschappij and The Nederlandsche Pacific Petroleum Maatschappij, respectively, subsidiaries of the Standard-Vacuum, Royal Dutch-Shell and the Standard Oil of California and The Texas Corporation.

Only the first two are producing at



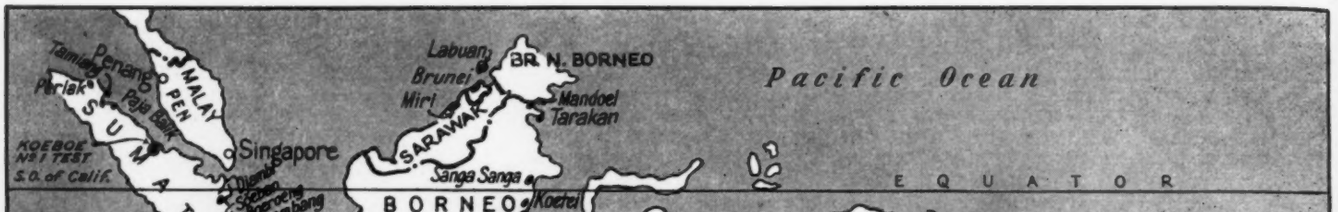
present. In one large productive area, the district of Djambi, South Sumatra, the Netherlands Indian Government is partner with the Bataafsche in a company called The Nederlandsch-Indische Aardolie Maatschappij (N.I.A.M.). This concern is also active in several smaller areas. In addition, there are several small independent companies, but their operations are on a relatively restricted scale.

Exploration is concentrated chiefly in the islands of Sumatra, Borneo, Java and New Guinea, though a re-examination of areas of interest in other islands is being made in the light of modern knowledge. The Pacific is interested chiefly in Central Sumatra and in West Java. The Koloniale and the Bataafsche are active over the whole archipelago, except New Guinea where all three companies have joined in the Nederlandsche Nieuw Guinee Petroleum Maatschappij to carry out what is probably the most complete geological survey ever undertaken. This work started with an aerial survey of a region more than three times the size of the combined producing districts of California. The geological survey has been in progress four years and important wildcat tests are now being drilled. Drilling of Wasian No. 1 was started February 28, 1939, and had reached a depth of 1348 ft. in mid-May. Preparations are under way for the boring of a second test, to be known as Seget No. 1.

The producing areas of the Netherlands Indies include North Sumatra, South Sumatra (and Djambi), East Java, the Tarakan and Samarinda regions of East Borneo, and Ceram. All the above areas have been known since the beginnings of the oil industry in the East Indies and all recent discoveries have been made in these same areas. As an exception to the above, a new producing center is being opened by the Bataafsche in the drainage basin of the Barito river in South Borneo.

In central Sumatra, where the Netherlands Pacific is exploring a concession of

Eastern end of the Miri, Sarawak, field operated by the Royal Dutch Shell interests. Due to declining output rotary methods are being applied in search for deeper horizons.

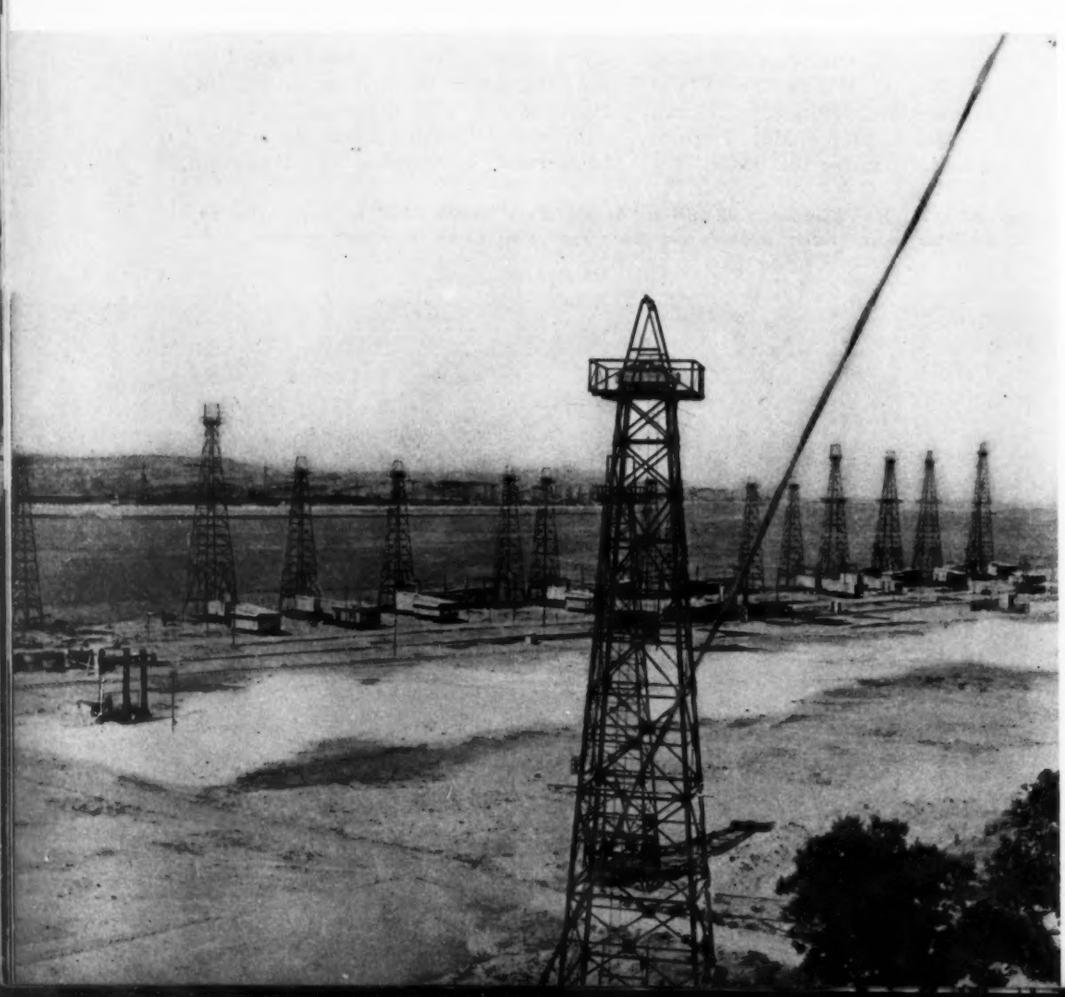


nearly 1,500,000 acres, particularly difficult conditions have been encountered. The area is less than 150 miles north of the equator, almost uninhabited, low and largely swampy and covered by a heavy jungle growth. At the beginning of the work native packers followed animal trails inland from the coast and slashed passages through the jungle. Some heavy equipment was transported up the Koeboe and Rokan rivers but before this could be done a vast amount of debris had to be cleared out and channels changed to allow even small barges to pass.

In 1938 a motor road was completed to the center of the area where, in addition to surface geology, seismograph and photogeological methods are being employed in the work of survey. As a result of the intensive studies of the past two years two locations for test drilling were selected, about 175 and 245 miles respectively from Medan, the operating headquarters. The first well did not find production and a second, Koeboe No. 1, was spudded in April 22 of this year and had reached a depth of 1386 ft. on May 19. Preparations for drilling another test are under way.

The several companies are very progressive. The use of modern equipment and technique is being rapidly extended, including Diesel powered drilling units, wire line core barrels, electrical coring, gun perforating, mud conditioning, squeeze cementing, smaller casing programs, deep slim bore holes for geological information, and new refinery methods to improve the quality of the products. Large extensions and modern equipment have been added to existing plants. Large refineries are located at Pankalan Brandan in North Sumatra, Soengei Gerong, Pladjoe in South Sumatra, Tjepoe in East Java and Balikpapan in East Borneo. Small refineries are located at Kapoean and Wonokromo in East Java.

All productive horizons are in Tertiary formations, for the most part at depths between 600 and 3000 ft. The most up-to-date producing methods are employed. The most progressive development is the conservation of reservoir pressure in the fields of the Koloniale in South Sumatra. Much



Chauk-Lanywa field in Upper Burma with the Irrawaddy river in the background under which the wells are being directional-drilled. The pictures on this and the facing page were takn by Allen Hicks of the Hydril Co.

of the original work in connection with the large-scale application of pressure maintenance methods was carried out in this company's fields. These operations began in 1929 and have proved to be remarkably effective, particularly in the Talang Akar field. Pressure maintenance has also been successfully applied to the adjacent Benaka and Djirak fields of the same company. They have been under observation for a sufficient length of time to demonstrate that they result in greater production efficiency and larger ultimate recoveries.

Modern methods of geological and geophysical exploration are in use. Geophysical methods find their widest application in the survey of the immense swamp regions of Sumatra, Borneo and New Guinea. This prospecting includes surveys with torsion balance, gravity meter, magnetometer and reflection seismograph. It is reported that 11 or 12 seismograph parties, and a slightly smaller number of torsion balance parties, are at work. The gravity meter is extensively used. Electrical prospecting has been introduced in South Sumatra. Deep exploratory drilling is being done and wells over 10,000 ft. in depth are not uncommon.

The geological activity in Java is mainly in the western part, where the B.P.M. is surveying an area of upwards of 800,000 square kilometres in the northern coastal plain. In Borneo geological and geophysical work has been proceeding for several years in the southern and western provinces. A large part of this area has been surveyed, but of late the exploration has been confined to the so-called "Amoentai Block," in the basin of the Barito.

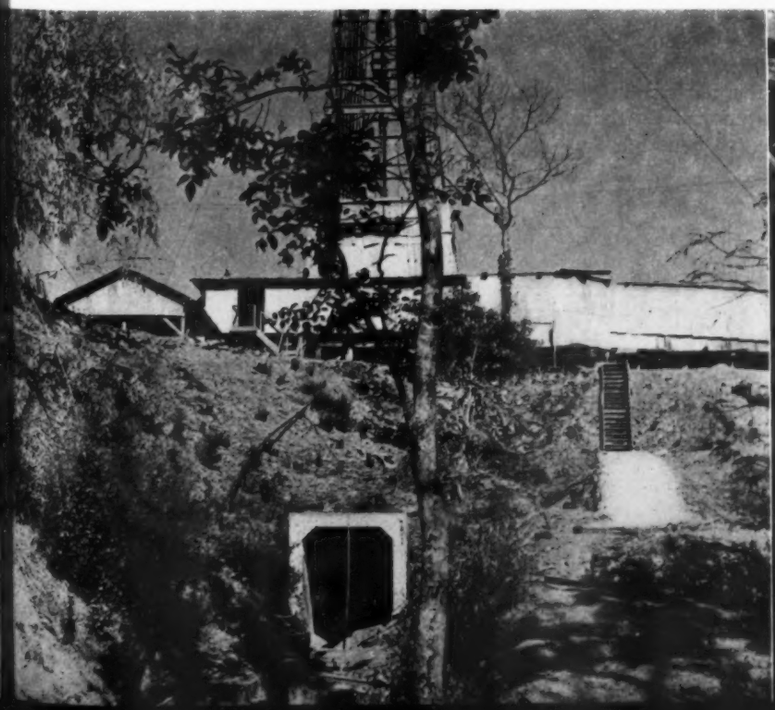
The constant development of drilling technique has rendered it possible to drill deeper and deeper wells. The deepest so far drilled in the Netherlands Indies is the one at Tjitaoe in West Java, which was abandoned as a dry hole at 3158 metres (10,263 ft.). This West Java area is particularly remarkable for very deep wells.

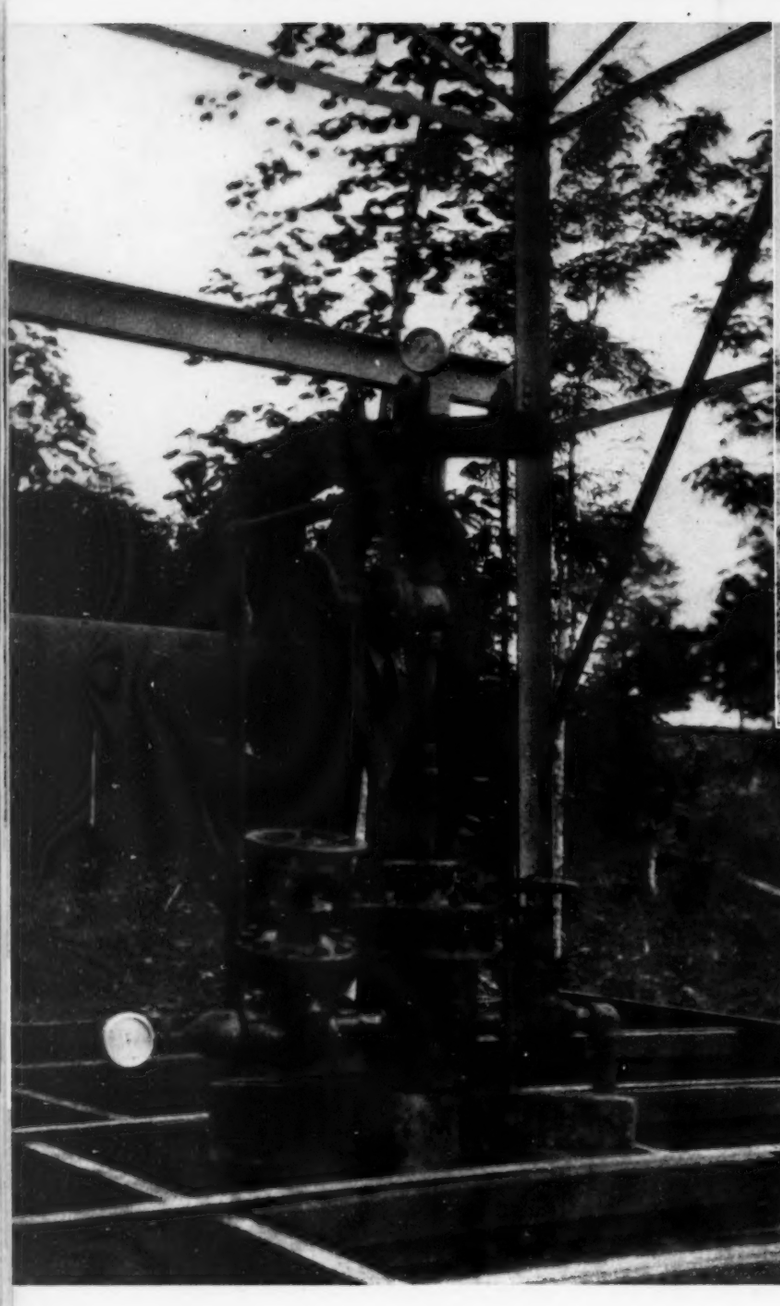
In addition to Tjitaoe, Bangadoea may be mentioned, where a depth of 3,000 metres has likewise been exceeded.

Of recent years particular interest has been shown in the Diesel outfit. Steam outfits require large and heavy boilers, which are not only difficult to transport, but also call for more fuel than a Diesel outfit. Diesel power is therefore preferred when work has to be carried out in fields which are remote or difficult of access.

A very important factor in the exploration of unknown regions is air mapping. The B.P.M. has repeatedly utilized this

Three views of Thayetmyo test in lower Burma, which is being drilled by Indo-Burma Petroleum Co. and may go below 10,000 ft. Above native driller in action; below left, the unusual entrance to the 40 ft. cellar where blowout preventor equipment is housed in anticipation of heavy pressures; below right, coolies making connection.





Left, typical well hook-up under pressure maintenance conditions on a Standard Vacuum well in Sumatra. Above, Pendopo landing field installed for areal survey of Standard Vacuum's contract area boundaries in Sumatra

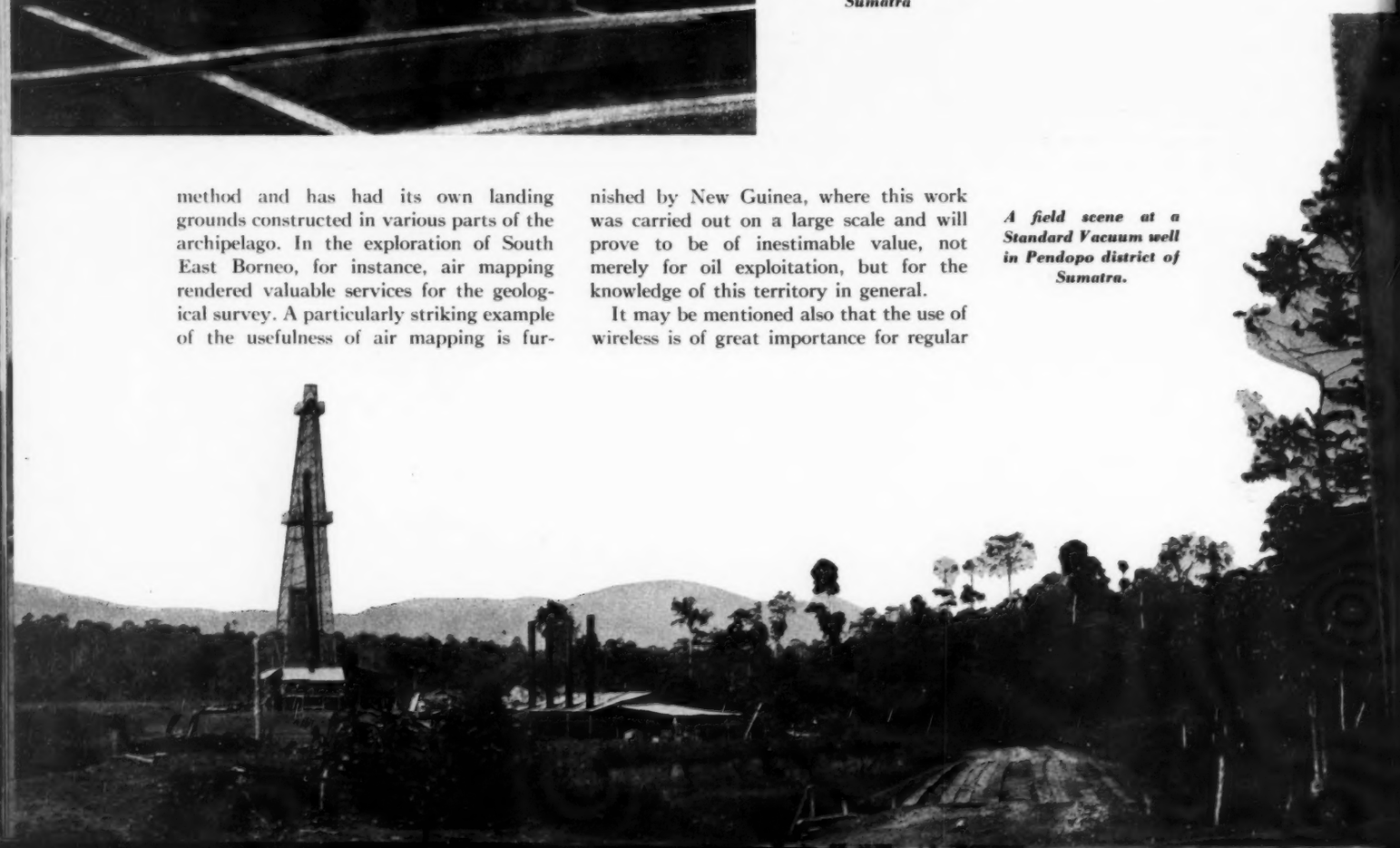
contact between the various geological expeditions and their bases, and therefore greatly facilitates the work.

Sarawak and Brunei have been producing fields for many years but renewed attention is being given to exploration work in both these districts at the present time. The former field dates back to 1909 when Sarawak Oilfields, Ltd., obtained a concession from the Rajah, Sir Charles Brooke. The first well was completed, as a producer, at Miri in 1910. Up to the end of 1938 the field had produced nearly 9,000,000 tons of

method and has had its own landing grounds constructed in various parts of the archipelago. In the exploration of South East Borneo, for instance, air mapping rendered valuable services for the geological survey. A particularly striking example of the usefulness of air mapping is furnished by New Guinea, where this work was carried out on a large scale and will prove to be of inestimable value, not merely for oil exploitation, but for the knowledge of this territory in general.

It may be mentioned also that the use of wireless is of great importance for regular

A field scene at a Standard Vacuum well in Pendopo district of Sumatra.



oil from 591 wells. Two main types of crude are produced, a non-waxy oil of 26.4 Baumé yielding about 13 percent gasoline, and a waxy oil of 40 Beaumé yielding 41 percent gasoline. The peak production was obtained in 1929 when the field produced 748,195 tons, but in 1938 production had declined to 203,429 tons and it is expected that this decline will continue, although, of course, at a much slower rate.

A charcoal gas absorption plant for the extraction of casing head gasoline is operated and the gasoline is blended with crude after which it is pumped to the refinery at Lutong, which is situated seven miles from the field.

A great deal of exploration work, both geological and geophysical, has been carried out in other parts of Sarawak and a considerable number of exploration wells have been drilled, but so far oil has been proved in commercial quantities only at Miri. Exploration work is still continuing on a considerable scale and, in addition to a program of deep drilling, a seismological survey is to be undertaken in the near future.

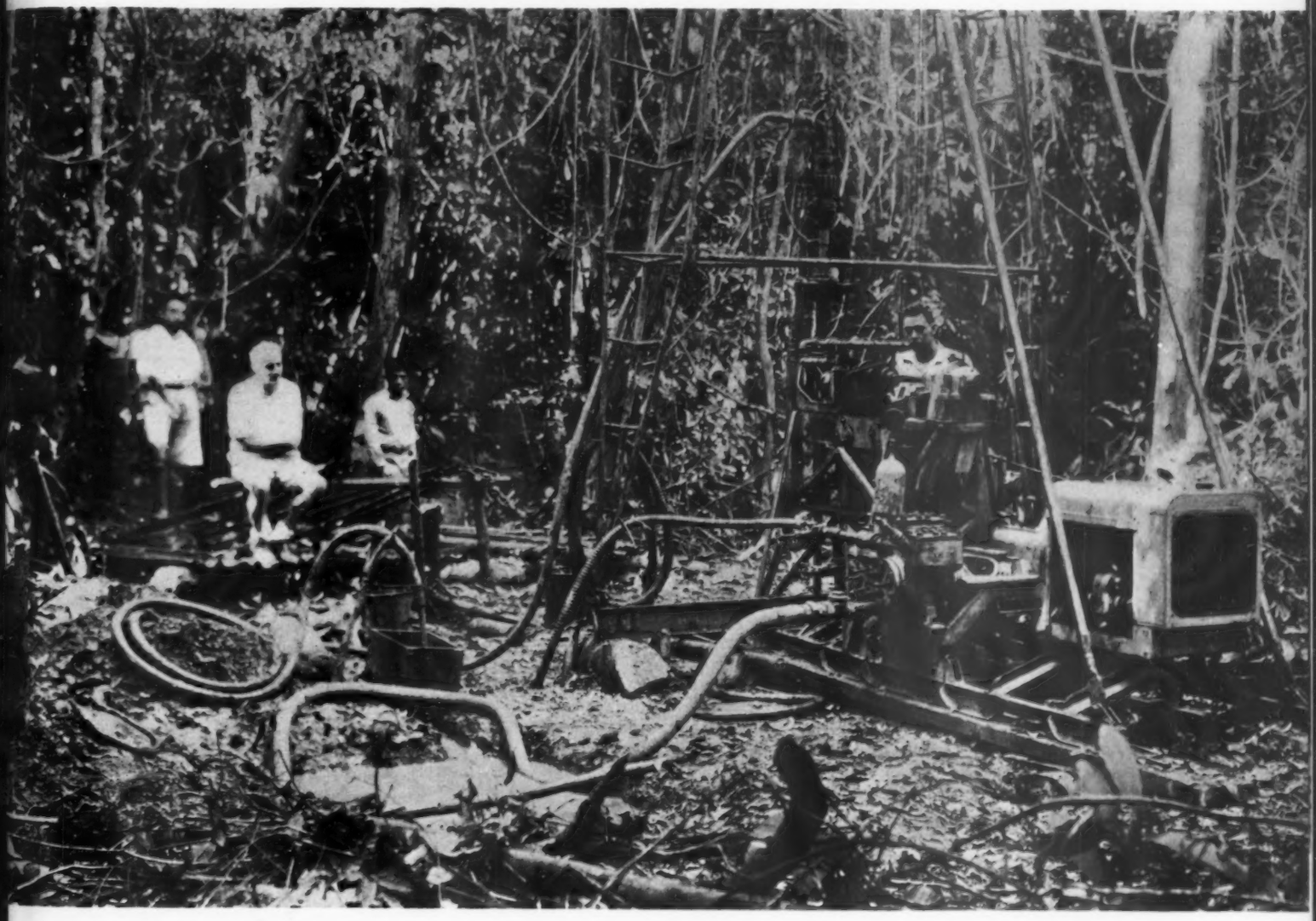
In addition to Sarawak a detailed investigation of the state of British North Borneo has been in progress during the last few years and this still continues.

In the neighboring state of Brunei geological work was started by the British Malayan Petroleum Company in 1922. A gravimetric structure was discovered near the coast at Seria and in 1927 a core drilling campaign was started across this structure. In one of the first holes oil was found at about 200 ft.

Exploitation drilling was started at Seria in 1928 and the first successful well was completed in 1929. The first oil level to be exploited at depths between 1,400 and 1,800 ft. produced a heavy non-waxy oil of 19.5 Baumé with only a small gasoline content.

In 1930 it was decided to explore for deeper levels and in 1932 the first light oil producer was completed at 5,280 ft. This light waxy oil is of 32.5 Baumé and yields an average of about 22.5 percent of gasoline.

The potential production of heavy oil is now 1,950 tons per day and of light oil 600 tons per day. In addition intermediate sands have been produced over certain parts of the field, one of which produces a light non-waxy oil. The productive sands extend under the sea and some wells have been drilled from offshore locations with foundations of precast concrete piles. Multiple wells are drilled to the several productive levels from each set of foundations. In order to overcome the high cost of these offshore locations, where possible, wells are drilled from the land and the hole deviated in order to tap the oil sand underneath the sea.

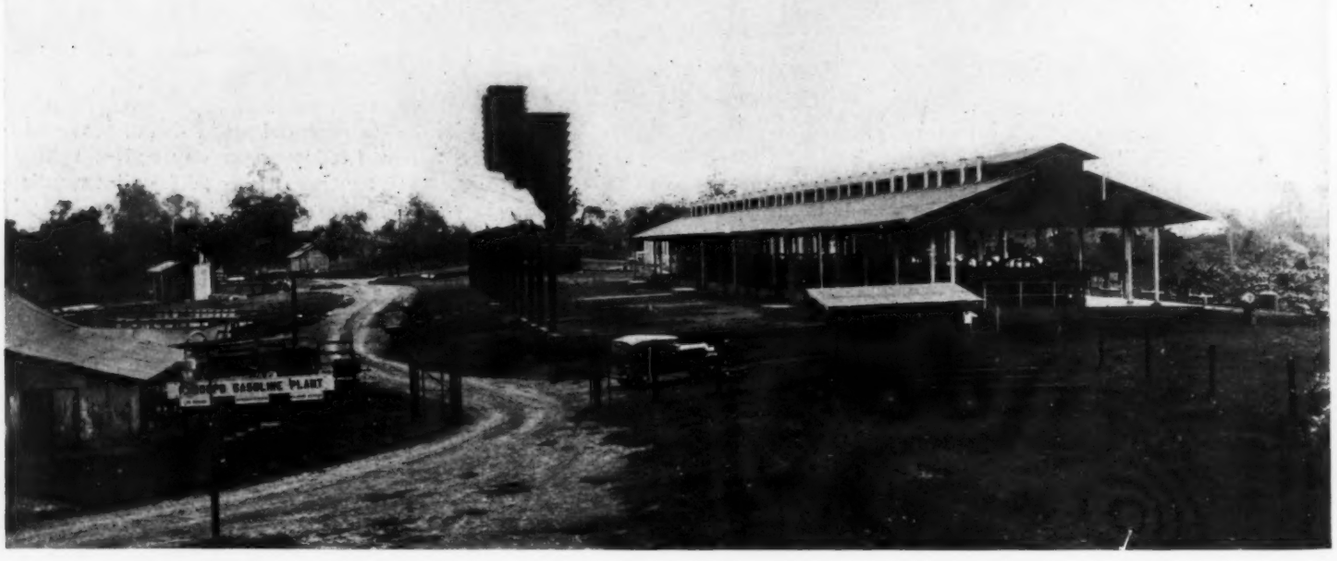


Core drilling in Netherland India.

All the production from Seria is pumped through a pipeline for treatment at Lutong refinery, which is situated about 27 miles along the coast. As the light oil wells are also big producers of high pressure gas there is a gas line to Lutong, where the gas is burnt as plant fuels.

Owing to the absence of a suitable

Above, Wilson-Snyder power pump en route to location in Netherland India, and below, Standard Vacuum's natural gasoline plant at Pendopo, Sumatra.

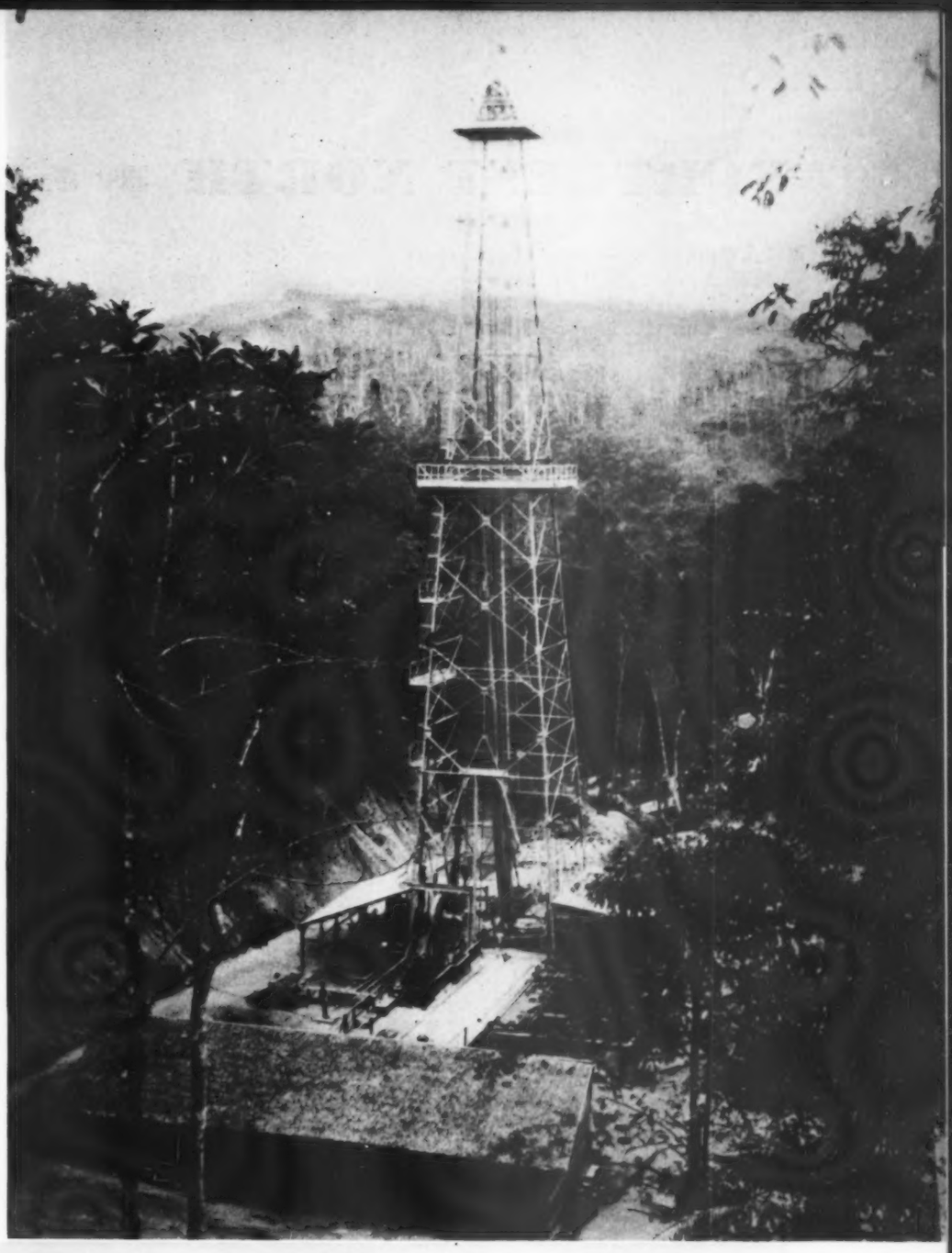


harbor, products are loaded into deep sea tankers at Lutong through submarine pipelines three miles long. There are five of these lines, three eight inch diameter and two 10-in. diameter; one of 12-in. diameter is now under construction.

Exploration work is being carried out continuously in various parts of Brunei and in the near future an exploration well is to be drilled at Jerudong, which is situated about 42 miles from Seria towards British North Borneo.

During the past year renewed attention has been directed to the possibilities of petroleum production in New Zealand and Australia. A number of large international companies have pooled their interests in the New Zealand Petroleum Company, Ltd. which is engaged in geological and geophysical exploration of the 2,782,500 acres for which prospecting licenses were obtained during the past year. Drilling was started late in 1938 in the Gisborne area, North Island, where the major part of the concession is located. The first test well, Totangi No. 1 was down to 3,600 ft. on May 19.

Five different sites in the Philippine Archipelago under consideration for oil exploration by the government are portions of the province of Leyte; the Bondoc peninsula in Tayabas; the provinces of Cagayan and Isabela in northern Luzon; Cebu province and Cotabato in Mindanao. Grant Corby, an oil mining expert, heading a survey party of four technical men left for Leyte April 12th. Five more geologists from the United States arrived at the end of the month and were immediately assigned to the other sites to be explored.



Sampang No. 1 of the N. V. Nederlandsche Pacific Petroleum Mij in Sumatra, right, and, below, river landing at Teloek Loeboek through which Standard Vacuum equipment was transported.

FURTHEST NORTH By James Collins

ALTHOUGH Alaska does not appear among the commercial producers of petroleum any review of world activities in drilling must take into account the operations now being conducted there. Two separate enterprises directed to the finding of oil are now in operation and two wildcats are being drilled with the most modern equipment available. Oil in small quantities has been found in Alaska in shallow wells and a substantial amount of capital is being risked to determine whether it may not exist in larger volume at greater depths.

One of these two attempts is a joint venture of Standard Oil Company of California, Tidewater Associated Oil Company and Union Oil Company. In 1938 an expedition sent north by these companies established a camp in Salmon Creek Valley, near Kanatak, five miles inland from Jute Bay. Materials and equipment had to be brought from California and Washington and a road built from the beach to the camp all of which required considerable time on account of the rough character of the country. During the summer, however, drilling was started on the first well, Grammer No. 1, on Bear Creek dome, and it was carried down 2,300 ft. despite difficulties of flowing water, lost circulation and bad weather before winter closed down operations for the season. Four of the crew remained in the camp during the winter months. The others went southward but returned with the opening of spring. Drilling was resumed and by the end of the third week in May the bit was down 3,000 ft. and still going.

On the Iniskin-Chinitna peninsula, on a site 168 miles southwest of Anchorage, an ambitious drilling project is being carried out by Iniskin Drilling Company. The company was organized by Russell E. Havenstrite and Carl H. Beal of Los Angeles after they had made a careful survey of the district. It started operations in 1936. Among the shareholders in the company, besides the originators are several Los Angeles business men and a group of well known Hollywood movie stars. To

Carl H. Beal at the wharf on Chinitna Bay where materials for Iniskin's Alaskan drilling venture are landed. Below the well and camp —note fuel oil drum to left.

date $700,000 has been spent on the venture.

At the end of the 1937 season's work, the hole was 5,051 ft. deep, with a string of casing cemented at 4,250 ft. and 337 ft. of surface pipe. The following May, the hole, which had been loaded with mud, was found to contain considerable gas and oil, and at 6,150 ft. several feet of sand were

Two views of the Salmon Creek camp in Alaska where Standard of California, Tidewater Associated and Union Oil Companies are drilling an important test.

passed carrying high gravity oil. There have been numerous showings from 4,700 ft. down, but drilling is being continued in the hope of reaching a thick oil sand. No limit has yet been set to the depth the company is willing to go. Pressure so high that great care has been necessary to prevent a blowout is considered an encouraging factor.

The drilling formations encountered at the outset were very hard, and the first season's progress was as little as two inches an hour. A newly designed rock bit stepped that up to two feet an hour the second season.

Thick shale bodies were encountered lower down, absorbing water from the mud, swelling and reducing the hole diameter, and creating another type of difficulty.

The Iniskin structure is an anticline, 12 miles long, approximately bisecting the peninsula. The surface is deeply eroded, and the country comparable to the Kettleman Hills North Dome structure in shape, dip of flanks and size, with more complexity due to minor faulting.

Formations penetrated have been Jurassic, with the likelihood of reaching the base of the Jurassic section, and finding heavy production in the underlying Triassic strata.

The debarking point for the well, on Chinitna Bay, has one of the highest tides in the world, ranging 32 feet. Safety requires anchoring supply ships six miles from the shore. At low tide, the company wharf is two miles from the ocean. These conditions have increased the operating difficulties, because unloading can be done only at high tides with the short drilling season, extending approximately from the middle of May to the end of October, the project has furnished unique problems. This year the drilling crew left Los Angeles on May 8 to resume drilling from 7,156 ft. at which depth work stopped last fall. With 100 lb. pressure, requiring 105 lb. mud, the prospects of finding production this summer are considered excellent.

The officers of the Iniskin Drilling Company are: Russell E. Havenstrite, president; Carl H. Beal, vice-president; William Ahrens, secretary and treasurer; Gran W. Corby, assistant secretary and treasurer. In addition, the directorate includes S. B. Mosher, Neil S. McCarthy and Hal E. Roach.

Extensive Exploration Awaits New Oil Law in ROUMANIA

BUCHAREST, ROUMANIA, MAY 12

PRODUCTION in Roumania which had reached a maximum during 1936, showed a decline for the second year in succession during 1938 although not as important as the fall between 1936 and 1937.

Roumanian Activity

Year	Production Tons	Change Percent	Drilling Meters	Change Percent
1936	8,704,000	....	328,000	....
1937	7,153,000	−18	394,500	+20
1938	6,603,000	− 7.5	285,000	−28

From the above figures it is seen that although there was an increase of 20 percent in drilling activity during 1937 compared with 1936, there was nevertheless an important decline in total production of 18 percent. In 1938 however, in spite of a decrease of about 28 percent in drilling activity, the corresponding fall in production was only 7.5 percent.

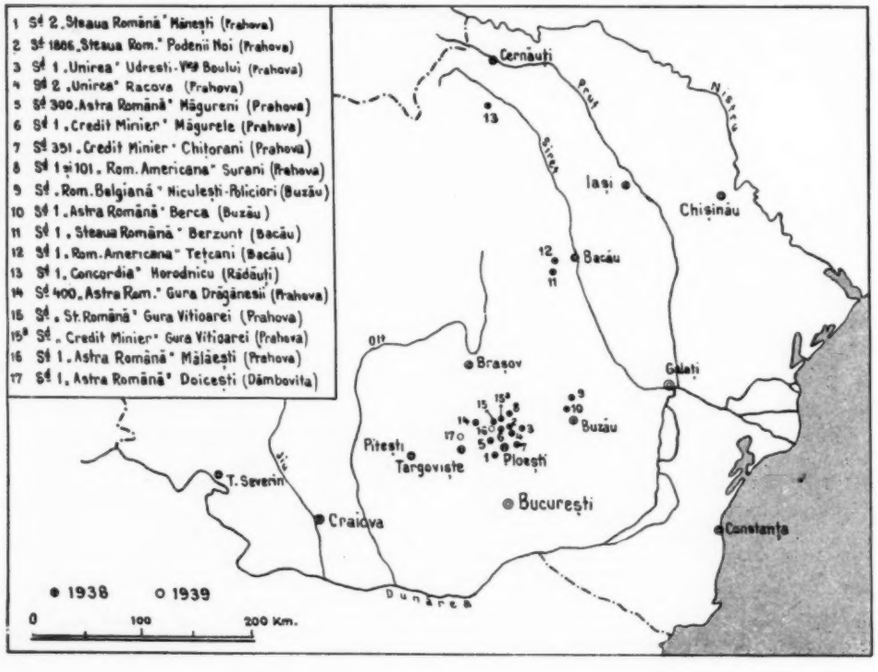
The decrease in drilling activity is chiefly due to the dearth of proven areas. During the past few years there has not been a correct balance between exploration and exploitation work in Roumania. The result of insufficient exploration work in the past is that today there is a definite shortage of proven lands.

As far as exploration is concerned, this has to be carried out almost entirely on State-owned lands and operators have not been over anxious to do this in the past because the present Mining Law does not present an incentive for anybody to risk the considerable capital involved in exploration work.

To make this point clearer, it must be explained that exploration work is usually carried out on what is known as State Exploration Perimeters. An operator obtains the right to drill one or more test wells on 2,500 acres of land. If commercial production is obtained then the successful explorer receives by way of an award, a percentage of the proven areas—the State disposing of the remainder of the proven area to the highest bidder. Operators have considered that the award is not commensurate with the risk involved.

The same argument applies to the larger areas which are now being offered for exploration in regions situated more than 20 kilometers from known production. These larger areas known as Mining Districts can be up to 250,000 acres in size but their development is slow and costly.

For the greater part of 1938 the Roumanian petroleum industry has been trying to get a revision of the Mining Law but due to the frequent changes at the head of the Ministry of National Economy, no Minister has been in charge of this very important department long enough to give sufficient thought to this law and revise those parts of it which no longer meet present-day conditions.


1 Sț 2, Steaua Română" Mănești (Prahova)
2 Sț 1886, Steaua Rom." Podenii Noi (Prahova)
3 Sț 1, Unirea" Udrești-Vîlsa Boului (Prahova)
4 Sț 2, Unirea" Racova (Prahova)
5 Sț 300, Astra Română" Măgureni (Prahova)
6 Sț 1, Credit Minier" Măgurele (Prahova)
7 Sț 351, Credit Minier" Chițorani (Prahova)
8 Sț 1 și 101, Rom. Americana" Surani (Prahova)
9 Sț, Rom. Belgiană" Niculești-Policiori (Buzău)
10 Sț 1, Astra Română" Berca (Buzău)
11 Sț 1, Steaua Română" Berzunț (Bacău)
12 Sț 1, Rom. Americana" Tețcani (Bacău)
13 Sț 1, Concordia" Horodnicu (Rădăuți)
14 Sț 400, Astra Rom." Gura Drăgănești (Prahova)
15 Sț, St. Română" Gura Vitioarei (Prahova)
15a Sț, Credit Minier" Gura Vitioarei (Prahova)
16 Sț 1, Astra Română" Mălăești (Prahova)
17 Sț 1, Astra Română" Doicești (Dâmbovița)
Cernăuți
Prut
Nistru
Siret
Iași
Chișinău
Bacău
Brașov
Galați
Buzău
Pitești
Târgoviște
Ploești
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The cost of a wildcat well has considerably increased due to a number of reasons chief among which are distance from the source of supply, increased depth, an increase in the cost of materials necessary for the drilling of such a well, and last but not least, increased taxation of one form or another.

Monsieur Bujoiu, the present Minister, who has had a vast experience in managing a large and important industrial mining company and is therefore thoroughly conversant with the present mining law, is considered by all as one of the best informed persons to be at the head of this department for a considerable time and it is earnestly hoped that he will not lose any unnecessary time before bringing about the desired change to the law. The petroleum industry has very recently presented the Minister with detailed proposals for a completely revised law which had been elaborated by the representatives of both national and foreign companies who, after very lengthy discussions, arrived at complete agreement and presented a joint scheme.

Since M. Bujoiu's advent to his present high office he has been busily engaged in perfecting the two very important trade agreements with Germany and France. In the near future a British delegation is also expected in Roumania and this will probably mean that the Minister will not be able to give much attention to the Mining Law until summer. But the whole industry eagerly awaits from M. Bujoiu revised mining law which will give the industry the impetus for which it has been waiting for the last 18 months or so.

An accompanying map shows the areas from which Roumanian production was obtained during the year. There were 145 wells which came into production during the year as compared with 207 for 1937. The old field of Moreni-Gura Ocnitei still occupies first place followed by Boldesti and Tzintea.

Relative Importance of Roumania Fields

Field	Percent of Total Production
Moreni—G. Ocnitei	45
Boldesti	15
Ceptura	10
Tzintea	9
Bucsani	6
Ochiuri	5

These fields represent therefore approximately 90 percent of the whole production of the country which is obtained from the three counties of Dambovitza, Prahova and Buzau.

As far as the drilling activity is concerned, approximately 32 percent was done in Tintea-Liliesti area, 23 percent in the Moreni-Gura Ocinitei area, 19 percent in Ochiuri, 15 percent in Ceptura, 8 percent in Boldesti, and 3 percent in the Runcu area.

The increased activity at Tzintea-Liliesti during last year is beginning to show its

effect during the present year; this is the first field in Roumania which is being rationally developed. The field which at present extends over a length of some 7 kilometers consists of two distinct flanks. The northern flank is being developed by each company according to its holdings, on an established spacing agreement. The southern flank is being developed under Unit operation. The development is rather slow owing to the great depths of the wells many of them exceeding 9,000 ft. and due also to the difficult nature of the drilling. The bit has to penetrate some 1,200 ft. of heaving shales and one or two holes have been lost on this account.

There were 16 wildcat wells drilled during the year 1938. An accompanying map, shows the location of these wells. The Manesti exploration has so far proved the existence of an important gas dome under very high pressure. Further exploration down the flanks of the structure will possibly find oil. Only one well (No. 6 on the map) has found oil in commercial quantities. The maximum production obtained from the sands so far tested was 50 tons per day. From surface indications it is reasonable to expect that an area of some 10 kilometers long might eventually be productive.

Of the wells started during 1938 the wildcat at Draganeasa (No. 14 on the map) has found oil and had a maximum production of approximately 50 tons per day.

None of the other tests wells completed last year or up to date have obtained commercial production.

The map also shows exploration wells which have been started this year. (Nos. 16 and 17).

The above of course does not take into consideration semi wildcats drilled to establish the extension of limits of already known producing fields.

The export price structure which had been steadily above the level of the Gulf declined towards the end of spring and beginning of summer in 1938 and increased slowly but steadily thereafter. Total exports of the country amounted to approximately 4,500,000 tons.

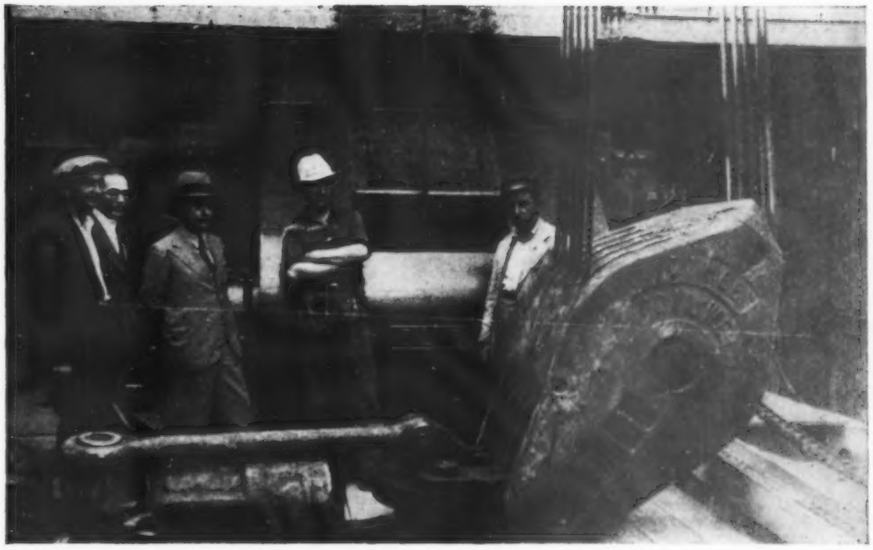
Germany, Austria and Czechoslovakia imported 22 percent of Roumania's oil exports, Italy took 12.5 percent, and England 12.0 percent.

Apart from the above, 8 percent of Roumania's total exports were supplied by way of bunkers to boats.

Of the total 75 percent was exported via Constanza and the Black Sea and 20 percent via Giurgiu up the Danube.

Domestic consumption of petroleum products showed an increase of 4 percent over 1937.

The important increase however is in motor fuel due entirely to the general improvement in roads and in particular to the completion of the Oradea-Oltenita road traversing Roumania from the Hungarian to the Bulgarian frontier. This road forms part of the London to Istanbul road.



© Oil Well Supply Co.
Rigging up one of the most modern rotary outfits in Europe at Tzintea, Roumania.

The consumption of motor spirit in 1936 was 86,800 tons, while in 1938 it reached 120,200 tons.

The present National Government under the guidance of King Carol II, has elaborated a vast programme of road construction and it is confidently expected that within a few years Roumania will have the best roads in the whole of the Balkans.

The production so far this year has been fairly steady at 1,750 tons per day and is likely to remain at around this level for the rest of the year until new and unknown sources are brought to light.

A new and better mining law coupled with a revision of the present high rates of taxation should result in increased exploration and the consequent discovery of new fields.

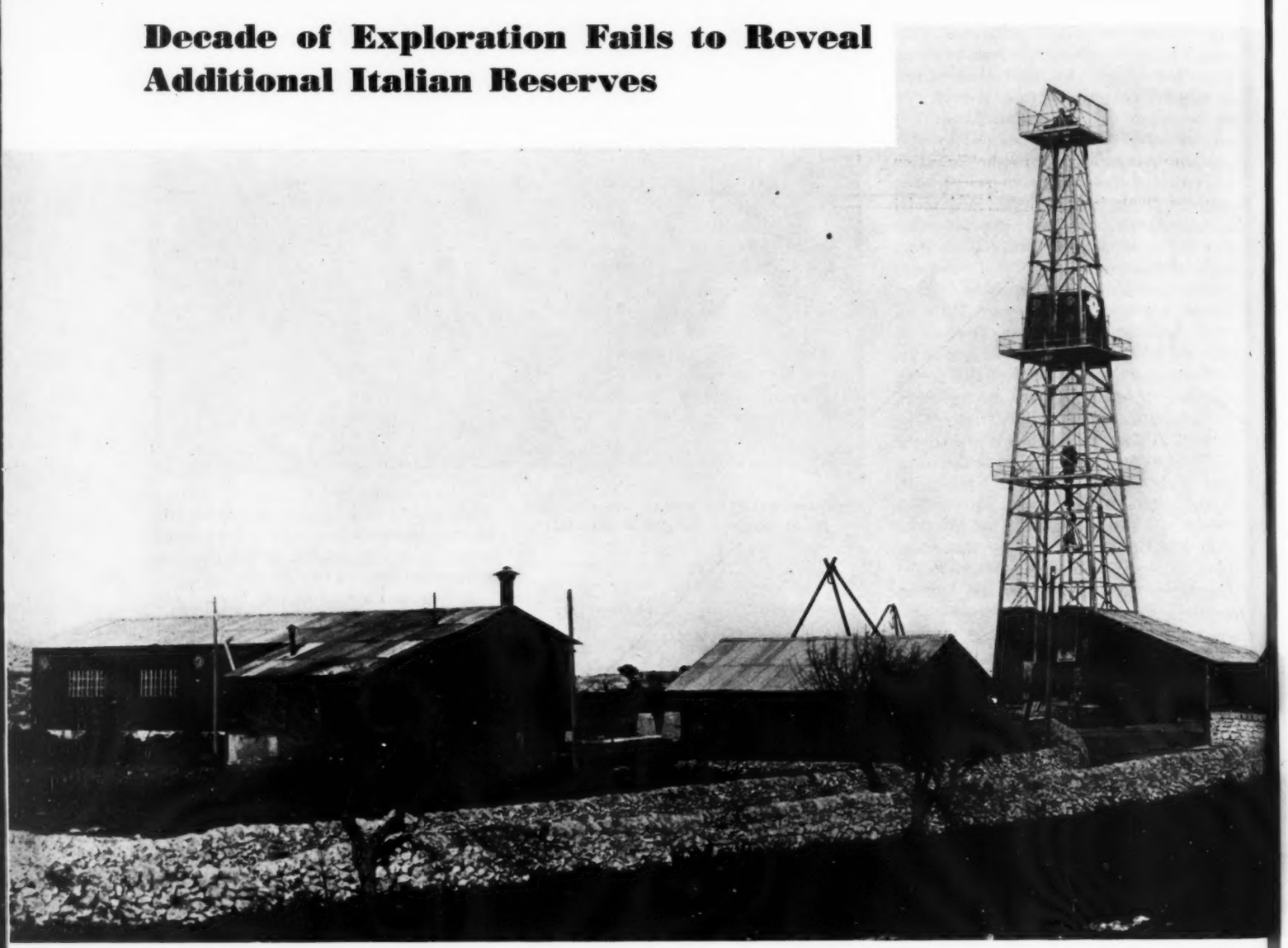
A certain number of big mining districts have already been awarded and operators are anxiously awaiting the revision of the law in order to start work. It is hoped the new law will be forthcoming in time to allow operators to use to the full, the good summer and autumn weather for starting their wildcatting operations. Roads in these outlying areas are very bad indeed and are only suitable for the heavy transports connected with drilling operations during the dry season.

Policy in Latin America

(Continued from page 43)

Likewise, this course of action is inimical to the best interests of the countries that are permitted to flout the rights of United States citizens and to seize their properties. Capital naturally will not continue to flow into places where it is subject to confiscation without recourse. As Secretary Hull has pointed out on more than one occasion Good Neighborliness cannot succeed as a one way policy, yet the Washington government continues to act as though that were feasible. Relations between governments are best conserved when there is a meticulous observance on both sides of the rights of each. By its course of non-resistance to the unfriendly acts of a very few of its southern neighbors the government of the United States is sacrificing its own standing and the rights of its citizens. More than that it is actually doing a disservice to all Latin America because the vast amounts of capital needed by its members for giving use and value to their great undeveloped resources cannot be obtained through loans or through seizures, but only by making the employment of private capital and enterprise safe and at least potentially profitable.

Decade of Exploration Fails to Reveal Additional Italian Reserves



IN 1859, when search for petroleum was begun in Pennsylvania, Italy had for several years been producing a few tons of oil. The discovery of great oil deposits in America stimulated oil exploration in Italy, as it did in other countries; in 1865 Italian production amounted to 2,965 bbl.

In 1866 Mayo and Botta were drilling at Fornovo Taro and Medesano, using American machinery and American technical personnel. In succeeding years other companies conducted exploratory drilling with improved systems and materials, but without the success which was easily obtained by similar enterprises in other countries. It was not until 1891, after various attempts that registered partial success and ephemeral results along with numerous complete failures, that the presence of oil in exploitable quantities was demonstrated in Emilia by the discovery of the Velleia field in the Valle del Chero (Piacenza). Other discoveries followed but it was not until 1915 that the S. Giovanni Incarico field was found in Terra di Lavoro, climaxing an intermittent and desultory era of exploration that began in 1871.

YEAR	TONS	YEAR	TONS
1910	7,069	1925	7,896
1911	10,390	1926	5,405
1912	7,479	1927	6,138
1913	6,572	1928	5,994
1914	5,542	1929	5,886
1915	6,105	1930	7,791
1916	7,035	1931	16,188
1917	5,668	1932	27,046
1918	4,907	1933	26,526
1919	4,851	1934	20,180
1920	4,937	1935	15,977
1921	4,648	1936	16,106
1922	4,290	1937	14,000
1923	4,701	1938	13,178
1924	5,505		

In 1918 there were two oil fields in Italy, the Montechino and Velleia fields, which had reached their peak production of 10,028 tons in 1911 and were now in their decline with a production of 3,748 tons in 1918. In 1918 the Vallezza field, also in Emilia, was found and in 1918 produced 758 tons. During that year the S. Giovanni field produced 343 tons.

The smallness of the national production in comparison with the country's growing civil and military needs for motor fuel and fuel oil (which now amount to about 4,000,000 tons) has caused the government to give serious thought to a solution of the oil problem. It was now evident that neither large tariff protection nor partial state aid in furnishing drilling machinery and material would be sufficient to induce private companies to undertake systematic exploration of the subsoil.

Private industrialists were clearly unwilling to employ their capital in explorations that involve huge investments and serious financial risks. The most they could be expected to do would be to make shallow drillings in those zones that offered immediate prospects without much expense;

this they could do with the help of tariff protection, bonuses (now 650 Lire per ton of gasoline and oil obtained from crude oils of national origin) and other advantages offered by the government, but these incentives were not adapted to produce results corresponding to national needs.

In 1926 the Italian government, having made up its mind to make a direct attack on this difficult problem, decided to set up a quasi-public organization which, while not putting obstacles in the way of private initiative, would pursue the following objectives:

Prosecute the search for oil in Italy.

Conduct exploration abroad in regions where geological studies have indicated some chance of success.

To exploit such oil fields as might be found.

To refine crude oils.

To supply oil products to the Italian market, whether of its own production or acquired from others.

To accomplish these purposes the A.G.I.P. —Azienda General Italiana Petroli—was founded with a capital of 100,000,000 Lire, in part furnished by the government. Subsequently this capital was raised to 300,000,000 Lire.

Since exploratory operations in the Italian petroliferous horizons would evidently require sums of money that could not be provided in the ordinary budget of the A.G.I.P., a special subvention for the prosecution of these researches was allotted from government funds.

The explorations made by the A.G.I.P. may be separated into three phases. The first extends from the end of 1926 to the middle of 1933; the operations in this period were mainly of a preliminary character and involved an expense of 40,000,000 Lire.

The second phase began about the middle of 1933 with the promulgation of Law No. 21 in July; this law provided for a basic Five-year plan for which was provided a fund of 90,000,000 Lire (of which only 70,000,000 was actually spent). The third phase began with the appropriation of 60,000,000 Lire (Decree Law of Jan. 9, 1939, No. 201) for continuing exploration for another five years.

In the period 1928-33 the A.G.I.P. succeeded in defining a petroliferous fold at Fontevivo, which yielded several thousand tons of oil. It was also established that the Appenine margin of Emilia, besides having interesting oil possibilities, is rich in natural gas which is now making important contributions to the national autarchy.

In the next period (1933-38) more powerful equipment was acquired and a program was adopted which called for deep drilling in those localities where geological and geophysical studies have indicated the existence of tectonic conditions favorable to the accumulation of hydrocarbons.

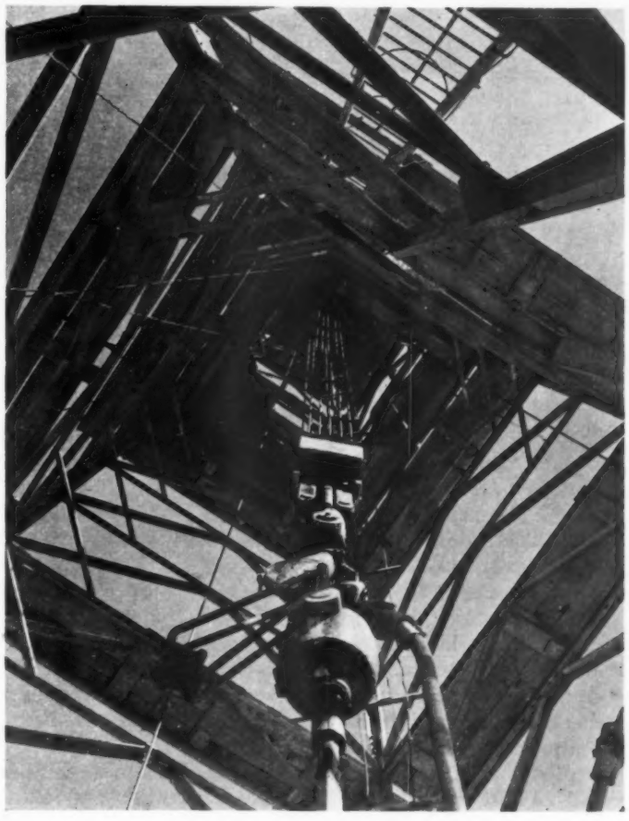
The program was vigorously prosecuted, but as work progressed geological conditions were revealed that altered opinions previously held; it was disclosed that the prospective oil bearing horizons, especially as regards the Po valley, lie at much greater depths than was at first supposed.

COLONIAL EXPLORATION

In addition to its work on the Italian peninsula the A.G.I.P. has taken up oil exploration in Italian East Africa where it is claimed that there are petroleum indications in continuance of the productive strata of the Arabian peninsula. Exploration is carried out principally in the Harar and in the Ogaden territories of Ethiopia, and on the Italian Somaliland plains towards the depression of the Auasc. In connection with exploration and drilling on the Red Sea side it should be noted that these have been developed both on the Western coast of the Buri peninsula in Eritrea, and between the Bu el Issar island and Cape Scioc representing the extremity of the Great Dalaac Island. Commander Cordero di Montezemolo during an hydrological campaign traced on the surface of the sea large oil patches from which samples were taken and analysed. The analyses showed that such oil had a specific weight of 0.890. Consequently it has been arranged for a geological mission provided with drilling machinery to carry out investigations on the spot. Drilling near the island of Bu el Issar has shown that after 116 meters of depth there are clayish formations which might represent the impervious formation above an oil resevoir. After these results were known in Italy an expedition with drilling equipment capable of reaching 1,000 meters, was sent to Great Dalaac Island and it is now reported that a salt dome was discovered at 300 meters. Latest news from Italian East Africa reports oil shows on this island but at present such reports have not been confirmed officially.

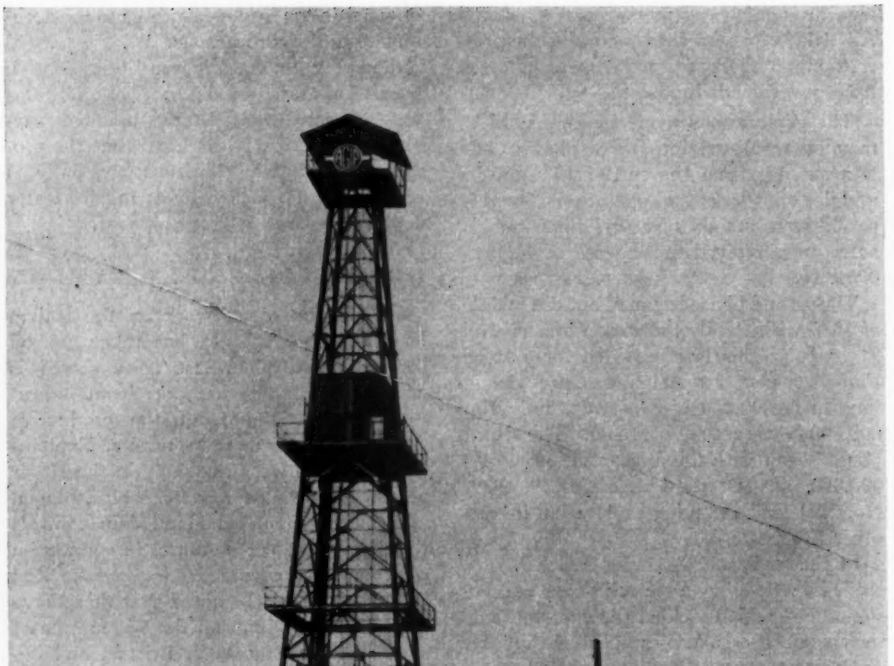
The A.G.I.P. is also carrying out important oil exploration work on the Eastern frontier of Lybia, but until now drilling to 150 meters has not revealed commercial deposits. According to the opinion of Italian geologists along that zone of Lybia there should be some extension of the Arabian oil resources.

Only important commercial production so far obtained by Italian oil exploration are those obtained in Albania by the Azienda Italiana Petroli d'Albania (A.I.P.A.) controlled by the Italian State Railways Administration which has acquired in March 1936 the concession on practically all the free Albanian areas for oil exploration. It should be noted that exploration and drill-



Left — Modern rotary plant used by Azienda Generale Italiana Petroli for drilling to greater depths (6,000 ft.) in Italy.

Right — Details of wooden derrick structure as erected by A.G.I.P. (government oil company) for rotary drilling.



The lower part of the derrick is enclosed for A.G.I.P.'s wintertime wildcat drilling activities in northern Italy.

ing in Albania by Italian interests started in 1926, and that in 1927 the Italian State Railways Administration had concessions covering 48,000 hectares and the Selemit, another Italian concern, had concessions covering 28,000 hectares. The oilfields controlled by the Italian enterprises are divided in three sections: at North near Scutari, at the center between Durazzo and Tirana and on the South between Valona and the Semeri river. According to the Italian geological estimates the possibilities of the present drilling work should result in a substantial increase over the present Albanian production of 356 tons per day. Further oil ressources should be found, judging from the present state of exploration, between Pechini and Elbassan and between Berat and Lushnia. The greatest activity of the A.I.P.A. is confined to the Devoil oilfields where 262,000 meters in 380 wells have been drilled.

This fact has prevented full execution of the program, both as regards the number of wells to be sunk and the total meterage to be drilled; the technical difficulties of deep drilling have slowed up the work.

Although what has so far been accomplished has not yet given definite, positive results, deep oil-shows and geopetroliferous elements have been recognized that have given reason for intensifying the explorations and for extending them to new zones which previously were not taken into consideration. It has been calculated that the actual expense sustained by the government in prosecuting oil exploration in Italy from 1927 to the present time has not exceeded 110,000,000 Lire. This means that the average annual expense for 12 years has been at the rate of 9,000,000 Lire (about $500,000) a year. This is a rather modest figure considering the extent of country to be explored and the difficulties presented by the geological constitution of the Italian subsoil; and it is not great in comparison with what other countries, where conditions are analogous to those of Italy, have spent and are still spending on their oil exploration.

The third phase of the oil search in Italy is now beginning; it starts off with a wealth of ideas and lessons acquired in a decade of experience which at least have yielded more precise indications than those afforded by simple surface indications.

Exploratory drilling in Emilia is to be carried to depths beyond 3,000 meters.

Without discussing the wells drilled along the flanks of the Appenines in Marcia and the Abbruzzi, it may be mentioned that a new drilling campaign, comprising 10 wells, is to be started in Sicily in order to test out certain interesting geological conditions and surface indications.

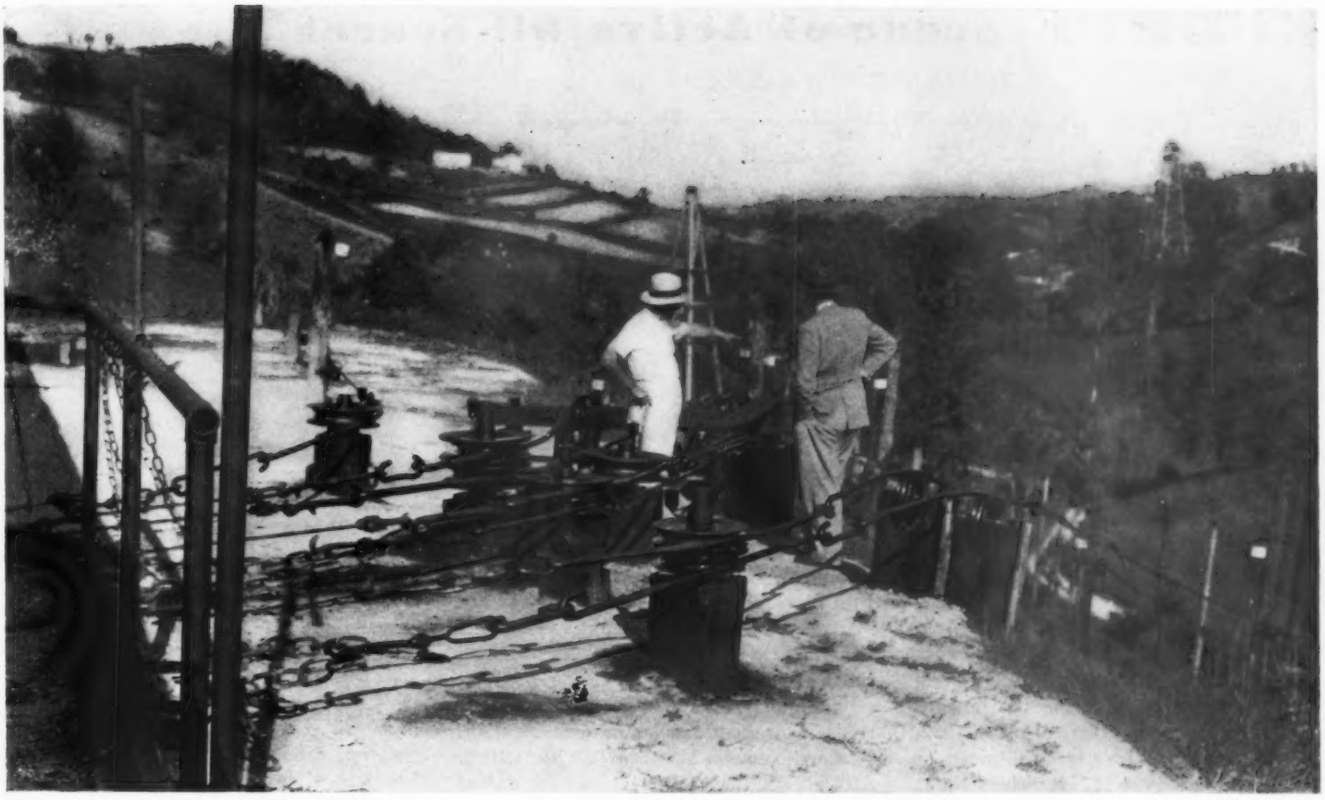
The 60,000,000 Lire that have been granted for the new Five-Year plan are intended exclusively for oil explorations within the kingdom. The cost of the search that was begun several years in Eritrea, and the one that was started a year ago in Libya, which are estimated to cost several millions of Lire, will be paid by the A.G.I.P.

GEOPHYSICAL

From 1927 to 1936 some 16,500 square kilometers in the Po valley were covered by the Eotvos method, requiring 9,425 gravimetric stations. On the basis of these geophysical researches the A.G.I.P. has drilled 75 tests, reaching in one case (Fontevivo, Province of Parma) a depth of 2,430 meters, besides several holes sunk to obtain geological information. To the gravimetric researches conducted in the Po valley there are to be added 1,263 stations where readings were taken in other regions extending over an area of 2,345 square kilometers.

To complete the picture of the geophysical researches executed by the A.G.I.P. there should be mentioned geo-electrical profiling of various regions with apparatus constructed in the scientific workshop of the Azienda and on which it has taken patents; some seismic and magnetic surveying has also been done.

These geophysical researches combined with geological studies have so far led to the



Centralized pumping in the Salsomaggiore field, one of the few producing areas in Italy.

drilling of several wells in the Po valley to depths ranging from 1,500 to 2,430 meters, 12 in Central Italy reaching a maximum depth of 1,950 meters at Fontespina (Province of Macerata), 14 in southern Italy with a maximum depth of 1,300 meters at S. Angelo (Province of Avellino), and five in Sicily which attained at Nicastro (Province of Siracusa) a depth of about 1,300 meters.

From the scientific point of view, a study of the drilling operations so far carried out leads to the conclusion that large deposits of oil may be found in certain regions of Italy, as in other parts of the world, for example California, at depths below any of those so far reached.

This conviction, which is now shared by nearly all Italian geologists, has led to a decision to put down some wells to reach depths beyond 3,000 meters; this work is now in progress with equipment suitably adapted for Italian purposes.

DRILLING METHODS

Methods of drilling vary with the character of the work, whether exploratory, which requires special precautions, or whether it is simply a matter of easy production.

The drilling now being prosecuted by the A.G.I.P. is still in the phase of exploration, and the various technical problems which have arisen have been greatly complicated by the intricate tectonics of Italian geological formations. This has made it necessary to adapt the system of drilling to the peculiarities of each zone.

While the formations that have been penetrated in Marcia have characters very similar to those encountered in the Po valley, those in the Abbruzzi are mainly calcareous, but sometimes siliceous and saliferous. In these formations the rotary apparatus has naturally not shown the same performance as in the marly sands of the Po valley. However the drilling value of the rotary apparatus is a direct function of the type of bit used. It now appears that by employing the Hughes and Reed bits, the use of the rotary outfit, which until lately was considered fit only for soft or semi-hard rocks, can be extended with success to drilling very hard formations.

As regards equipment for carrying out its exploratory drilling, the A.G.I.P. has had to rely principally on state-owned percussion drilling outfits acquired in the form of war reparations, and to adapt them, with substantial modifications, to the nature of the horizons to be perforated. But since these outfits do not have sufficient power for deep drilling and are costly to operate because of the slow rate of making hole, there have been purchased six modern rotary rigs capable of drilling 1,500 to 2,500 meters deep.

Besides these six rotary rigs there has been designed and constructed another high-power rotary outfit for drilling deeper than 3,000 meters. All the drilling rigs owned by the A.G.I.P. are driven by Diesel engines modified to work on natural gas where this fuel is found in sufficient quantity. In general, the Diesel engine has proved well adaptable to drilling conditions in Italy. One reason that speaks for the Diesel is the difficulty of obtaining a supply of good water for steam rigs, and the difficulties of transporting large boilers.

Specifications of the drilling rig that has been acquired for drilling below 3,000 meters call for three Diesel engines of 350 h.p. each, two for operation and one for reserve. Tool joints are chrome-nickel steel of the A.P.I. full hole type. Drill collars are the A.P.I. double female type with elevator recess only, and are each 10 meters long. A full set of bits of the most up to date type have been provided. The drill pipe is A.P.I. seamless tube except for the heavier sizes. These tubes are made in Italy by the Stabilimenti Dalmine (Bergamo) which has supplied the A.G.I.P. with all the tubing so far required.

For the coming third period of the oil search (1938-1943) the A.G.I.P. will discard its antiquated and uneconomic percussion drilling equipment and will be on a rotary basis.

EUROPE Scene of Active Oil Search

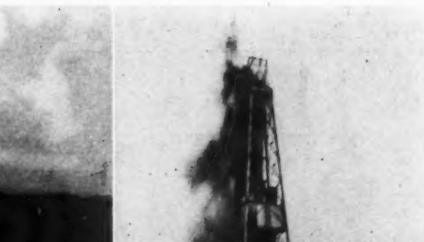
CURRENT British oil search is a serious one, and expenditure has been about $5,000,000 during the past three-and-a-half years.

British Drilling Campaign 1935-1939

	Major Tests		Geological	
ENGLAND—	**No.**	**Ft.**	**No.**	**Ft.**
D'Arcy Exploration	9*	57,171*	24‡	11,277‡
Anglo-American Oil	1	3,506	2‡	321‡
Gulf Exploration	1	5,600	2	975
Steel Bros.	1	757	...	.....
Total, England	12	67,034	28	12,573
SCOTLAND—				
D'Arcy Exploration	3‡	6,743‡	10	4,506
Anglo-American Oil	3§	8,377§	...	.....
Total, Scotland	6	15,120	10	4,506
TOTAL, BRITAIN	**18**	**82,154**	**38**	**17,079**

NOTE: Gulf and Steel Bros. are each preparing to sink another deep test and D'Arcy to drill two additional geological holes.
*Two still drilling. ‡One still drilling. §One testing.

The drilling license held by the Duke of Devonshire for the Hardstoft area, in Derbyshire, which already had been tested by three wells, was transferred to D'Arcy Exploration Company (Anglo-Iranian subsidiary) in 1938. Hardstoft No. 1 well originally was drilled during the government's drilling campaign of 1918-1922, when a flow of oil had been obtained at 3,130 ft. From 1919 to 1937 it yielded about 24,500 bbl. Output in 1937 was a mere 217 bbl. and much work had to be done to recondition the well. It was deepened to 3,272 ft. and following solvent and acid treatment, production tests were started in March, 1939, and at the end of April the well was producing steadily at about 15 bbl. daily.



Above, drilling the Gulf Company's dry hole at Penshurst, England, and, right, Anglo-American's Midlothian No. 1 in Scotland.

Although Anglo-American Oil Company Ltd. (Jersey Standard subsidiary) did not start its drilling campaign until 14 months after D'Arcy Exploration Company it had the first successful results and is the only producer of the current campaign. American's Midlothian No. 1 well near Dalkeith, Scotland, came-in at the end of June, 1938. After drilling to 3,857 ft. it was decided to test the most promising zone—1,733 to 1,760 ft.—and it has now been on the pump for several months. Total output to mid-May was over 1,400 bbl., the present rate being 40 to 50 bbl. per week.

Midlothian No. 2 reached 2,942 ft. and testing of several zones is in progress—Schlumberger tests have shown porosity to be disappointingly low. No. 3 well has been drilled to 1,760 ft. Tests are now in progress, the main oil horizon having been found at 1,715 ft. while two gas horizons have an aggregate potential of 1,270,000 cu. ft. daily.

D'Arcy has completed two deep tests adjoining and is drilling a third. In Cousland No. 1 five gas horizons were encountered with a potential of 10,450,000 cu. ft. daily.

Further south, at Eskdale, near Whitby, England, two wells have been sunk by D'Arcy—the first was abandoned due to broken tools, which three sidetracks failed to clear. In the second a strong show of natural gas was encountered at 4,212 ft., the significance of which is being tested.

At Gun Hill, near Leek, Staffordshire, a test well was sunk to 4,629 ft. Indications of oil were found in the Millstone Grit and

Deep Tests Drilled in Current British Campaign

D'Arcy Exploration Co., Ltd.—

Portsdown No. 1, Portsmouth, Hants., Eng.—6,556 ft.—Dry hole.
Hentield No. 1, Steyning, Sussex, Eng.—5,105 ft.—Dry hole.
Kingsclere No. 1, Kingsclere, Hants., Eng.—5,125 ft.—Dry hole.
Eskdale No. 1, Whitby, Yorks., Eng.—2,486 ft.—Hole blocked.
Eskdale No. 2, Whitby., Eng.—4,260 ft.—Drilling ahead.
Cousland No. 1, Dalkeith, Midlothian, Scot.—2,917 ft.—10,540,000 cu. ft. gas per day.
Cousland No. 2, Dalkeith, Midlothian, Scot.—2,432 ft.—Testing.
Cousland No. 2, Dalkeith, Midlothian, Scot.—1,400 ft.—Still drilling.
Gun Hill No. 1, Leek, Staffs., Eng.—4,629 ft.—Oil shows.
Eakring No. 1, Ollerton, Notts., Eng.—1,222 ft.—Still drilling.
Poxwell No. 1, Weymouth, Dorset, Eng.—1,666 ft.—Dry hole.
Hankham No. 1, Pevensey, Sussex, Eng.—842 ft.—Dry hole.
Hardstoft No. 1, Hardstoft, Derby, Eng.—3,272 ft.—Deepened from 3,130 ft. and reconditioned for 15 bbl. daily.

Anglo-American Oil Co., Ltd.—

Grove Hill No. 1. Hellingly, Sussex, Eng.—3,506 ft.—Failed to encounter natural gas sand of nearby Heathfield.
Midlothian No. 1, Dalkeith, Midlothian, Scot.—3,857 ft.—Several sands; oil at 1,733-60 ft., 6½ bbl. daily average.
Midlothian No. 2, Dalkeith, Midlothian, Scot.—2,942 ft.—Testing
Midlothian No. 3, Dalkeith, Midlothian, Scot.—1,760 ft.—Oil at 1,715 ft.; 1,270,000 cu. ft. gas daily.

Gulf Exploration (Great Britain) Ltd.—

Penshurst No. 1, Penshurst, Kent., Eng.—5,600 ft.—Dry hole.

Steel Bros. & Co., Ltd.—

Edale No. 1, Edale Valley, Derby, Eng.—757 ft.—Abandoned—water trouble.

in the Limestone Shales but, as the Carboniferous Limestone was barren of oil indications, the well was abandoned.

A deep test is being drilled at Eakring, Notts., to test the Carboniferous series based between 3,000 and 3,500 ft. This well is situated about seven miles north-west of Kelham, where two wells were drilled in 1923 by Oilfields of England Ltd.; although the latter encountered several shows of oil and gas, no commercial deposits were found.

In the south of England the only activity is the sinking of a second geological bore at Chaldon Down, Dorset, by D'Arcy, on the results of which depends the decision as to whether any further work will be carried out in that area.

Gulf Exploration Company (Great Britain) Ltd. completed a dry hole at Penshurst, Kent, late in 1938, and is planning to drill a second test in the Cleveland Hills, 100 mi. north of London. As a road must first be built the well will not be spudded for 30 or 45 days.

The only other participant in the search is Steel Bros. & Co. Ltd., which concern drilled a well in the Edale Valley, Derbyshire, without obtaining free oil. The company is shortly to start a second well, probbly at Alport Valley, in the Peak district.

Licensed Areas in Britain

	Granted	Abandoned (in square miles)	Held
D'Arcy Exploration Co.....	10,014	2,851	7,163
Anglo-American Oil Co...	2,487	300	2,187
Gulf Exploration Co.....	1,946	438	1,508
Steel Bros. & Co.....	350	.....	350
Total.....	14,797	3,589	11,208

FRANCE

Military demands have induced France to intensify oil prospecting during the past few years. The only proven petroliferous area is that of Pechelbronn, in Alsace, which produced some 500,000 bbl. in 1938. Last year the company had 33 rigs active, reaching most oil-bearing horizons at 1,209 ft. Water flush percussion system is the most economical down to about 1,200 ft., but wells below that employ rotary methods. A high-powered rotary outfit has been in operation for some time and a medium sized rig is on order.

During 1939 drilling operations are to be even more active and additional deep exploration wells will be sunk. Pechelbronn S.A. has received a permit to drill at Sundhouse and in Haute Savoie; these tests will be bottomed at 3,600 and 5,400 ft. respectively.

Other drilling operations in France are almost exclusively carried on by the government's Office National des Combustibles Liquides. The assets of the O.N.C.L. amount to $318,000, but in May, 1938, provision was made for $1,245,500 credit for that year's activities and an additional $1,139,500 for 1939. At the end of 1938 the amount invested in the French oil search was $1,855,000.

The O.N.C.L. received exclusive permit to prospect in areas of Herault, Houte Savoie and Puy-de-Dome. A research center was established at Montpellier, in Herault, and two rotary rigs capable of reaching 9,000 ft. were put in operation in the regions of Languedoc and Petites Pyrenees. At Pic Saint-Loup, about 15 mi. north of Montpellier, one test had reached 3,000 ft. at the beginning of 1939 and was approaching possible petroliferous horizons when it encountered broken structures and was abandoned. A second well is being drilled on the anticline and another will be sunk near Toulouse. In January a wildcat was spudded at the Saint-Marcet anticline (also in Herault), which has reached 2,250 ft.

In the Gabian district, Languedoc, 14 wells were brought-in during 1938 with a total output for the year of 156,000 bbl. Four are still operating, with a daily output of about eight barrels.

A rig at Pezenas, near Beziers in Herault, reached 3,468 ft. and passed through an impregnated layer at 2,400 ft. As this was for geological information only no production test was made, but a test well will shortly be sunk in the same district through the northern flank of the Pezenas anticline.

It will have to reach 6,000 ft. to pass through the Trias.

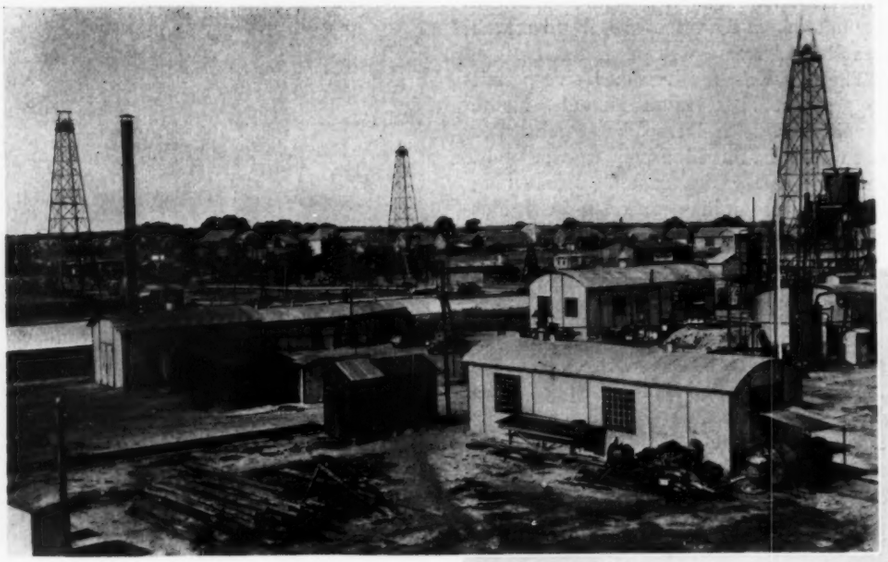
A well at Gornies, Herault, has reached 1,368 ft. but s being retarded by water trouble. Operations will be continued until the limit of the rig has been reached and should this prove unsuccessful another hole will be sunk with a more powerful outfit.

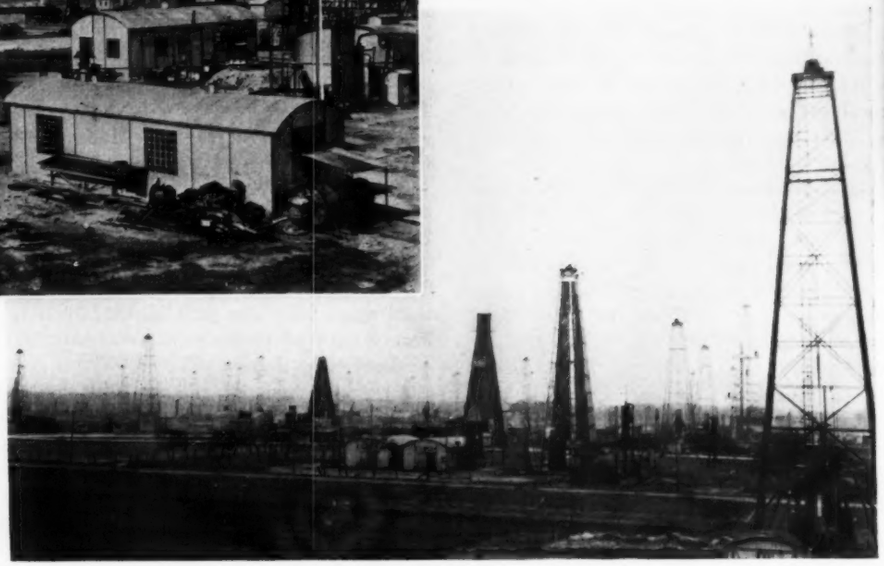
Several prospecting rigs are being prepared for testing the departments of Haute Savoie and Jura, while another rig will be put in operation at Rocquefort, in Landes. The O.N.C.L. will continue these operations for several more years, until the oil-bearing potentialities of France have been determined.

Above, combination cable tool and rotary rig at Pechelbronn, France, where drilling is now going on: hitherto production was obtained principally by mining.

Below, modern heavy drilling rig of the Office National de Combustibles Liquide in France.

Left, geological drilling for Societe Procedes Rodio. Every effort is being made to develop further production in France.





Above, view of the Deutsche Vacuum A. G. lease in Nienhagen, most important producing field in Germany, and right, another view of this field.

GERMANY

Drilling operations in Germany were intensified during 1938 due to the assistance granted by the Reich. Inaugurated in 1933, this policy has led to the discovery of 13 new proven areas and 35 producing wells. Compared with 810,000 ft. drilled in 1937 some 855,000 ft. were sunk in 1938, of which 285,000 ft. were in proven oilfields.

Crude oil output in Germany during 1938, excluding Ostmark, amounted to 3,850,044 bbl. and the comparative daily average for the first quarter of 1938 and 1939 shows a marked increase in production. Of this amount more than three-quarters is from the Hanover fields and the increase is due to the Nienhagen field, which compensated for the drop at Oberg and Wietze. Other fields are characterized by an increase of almost 300 percent of the 1937 figure as a result of the opening of the Reitbrook field, near Hamburg, where ten wells were brought in. The first well, completed in 1937, is still flowing 1,040 bbl. daily. Reitbrook has not yet reached its peak of development and it is claimed that it may rival Nienhagen.

Ostmark—Production of petroleum in Ostmark (former Austria) was already on the increase when annexed by the Reich; output in 1938 was 370,038 bbl. The Zistersdorf field, Vienna district, has 12 wells producing from the 6,000 ft. level with an aggregate output of some 2,100 tons while an exploratory well drilled in January, 1939, had an initial flow of about 20 bbl. The Geiselberg field has an output of 1,600 bbl. daily from four wells between 1,236 and 3,570 ft., but production has to be held down due to lack of transportation facilities. New areas are being tested in Ostmark, the most interesting of which is Sankt-Ulrich where a test produced some 49,400 bbl. daily. Prospecting will be undertaken in the Styria district, especially in the vicinity of Gratz, where there is hope of further discoveries.

Peculiar small derricks in the Witeze field in Germany.

Slovakia—Now that the oilfields of Slovakia are controlled by the German Reich it is quite likely that production from that area will increase appreciably during 1939 and 1940. Proven oil resources were considerable before the annexation and production had been held back only because of the former Czechoslovakian government's desire for a war-time reserve. Wells in the state-owned field of Gbely (or Egbell) produced mainly from the 525 ft. level and the deepest did not exceed 850 ft. Several smaller fields of local importance exist at Bohuslavice, Turzova and Mikova which may now be expanded.

Moravia—The principal oilfield in Moravia (also part of former Czechoslovakia) is that of Hodonin (or Goding), which is operated by the "Apollo" concern of Bratislava. About 40,000 ft. of hole is drilled in the field each year, which is fairly high considering that much of the production is obtained from the 460 ft. level—although the newer wells reach a maximum of 2,950 ft. Shallow production is a heavy crude, but

Devoli field in Albania, principal Italian controlled oilfield. Pipeline runs to the Adriatic and tankers carry the crude to Italian hydrogenation plants.

that from the deeper sands is lighter and comparable with oil obtained at Zistersdorf, in Ostmark. An additional field has been developed at Vacenovice, for gas production only. Deposits have been found at Watzinowitz, Zborowitz and Sokolnitz, which have raised hopes that this area may increase in importance as an oil producer.

POLAND

Polish production had declined in 1937 to an index of 65.5 from the 1928 production due to progressive exhaustion of the wells, and the government finally realized that if Poland's resources were to be augmented that it was necessary to rectify the prohibitive mining laws and encourage private enterprise. Much constructive work along these lines was accomplished, and the state-subsidized Pioniér concern immediately began an intensive campaign to discover new reserves. Socony-Vacuum interests also augmented the list of prospectors and the Pollon company (associated with Polmin) drilled a number of wildcats in the Kolbuszowa district after getting encouraging indications of oil and gas from geological surveys. The result of this exploration was the extension of existing fields and in 1938 production rose slightly and seems to be continuing its slight gain in 1939.

A new oil company, the Hanka, has been formed for development of the oilfields near Gorlice and is drilling near Lipinki, not far from the Rozdziele drilling operations. The Jakob Schmer Company, active at Lipink-Kryg, has just purchased a new drilling outfit in the United States, and plans to acquire an additional eight or ten rigs. Another company has started test drilling near the village of Rzepienniki, in the northern part of the Gorlice field, while according the Gazeta Handlowa, a rich oil deposit has been discovered at 220 ft. some three miles north of Jaroslaw.

HUNGARY

Although the Hungarian government has carried out an appreciable amount of exploratory drilling with favourable results at Buk Kszek, most of the activity in Hungary has been in the 8,000,000 acre concession of Jersey Standard's subsidiary, European Gas and Electric Company. The concern has completed 19 wells in the Lispe area to-date: two at Mihalyi; one at Gorzoteg; one at Duke; and 15 at Buda, of which two are being tested. A wildcat is still drilling at 8,333 ft. at Magyar St. Miklos, east of Buda, and is the deepest test in the country. The shallowest producer is Buda No. 3, at 787 ft., while Mihalyi No. 2 reached 8,104 ft., but the average depth is 4,905 ft. Production was first obtained at the end of 1937, and cumulative output of the Buda field to March 31st, 1939, aggregated 466,640 bbl—Daily average is now 1,411 bbl. A $125,000, gasoline recovery plant is being constructed to utilize oilfield gases.

Originally it had been anticipated that Hungary would be able to meet its own consumption requirements by September, 1939, but that is no longer considered likely. To facilitate transport a 3,500 bbl. daily capacity pipeline is being built from the Lispe fields to the railhead and extentions to the refinery at Almasfuzeto and the Csepel free port is contemplated for 1940.

Small exploratory outfit for geological prospecting to depths of 150-200 ft. in Germany on the left, with an entirely enclosed rig at Oberg.

OTHER EUROPE

Anglo-Portuguese Oil Company Ltd. acquired an exclusive concession to drill for oil over the whole Portuguese republic last year. Geological and geophysical surveying is being carried out and it is understood that the company has decided to commence drilling at a site about 30 mi. north of Lisbon.

Rotary drilling plant capable of reaching 3,000 ft. has been ordered by Western Greece Oil and Asphalt Company for prospecting on its 100,000 hectare concession in Epirus, northwestern Greece. A feature of the area is a large outcrop of asphaltic oil sand, which is easily mined and ready for direct use. A 250 ft. tunnel has been driven into one of the hills in the Molitza Valley to determine the economic value of the formations.

The department of mines of the Bulgaria Ministry of Commerce will carry out research work as to deposits of petroleum this summer, and a commission of mining engineers will investigate the oil deposits in the Warna and Prowadia districts.

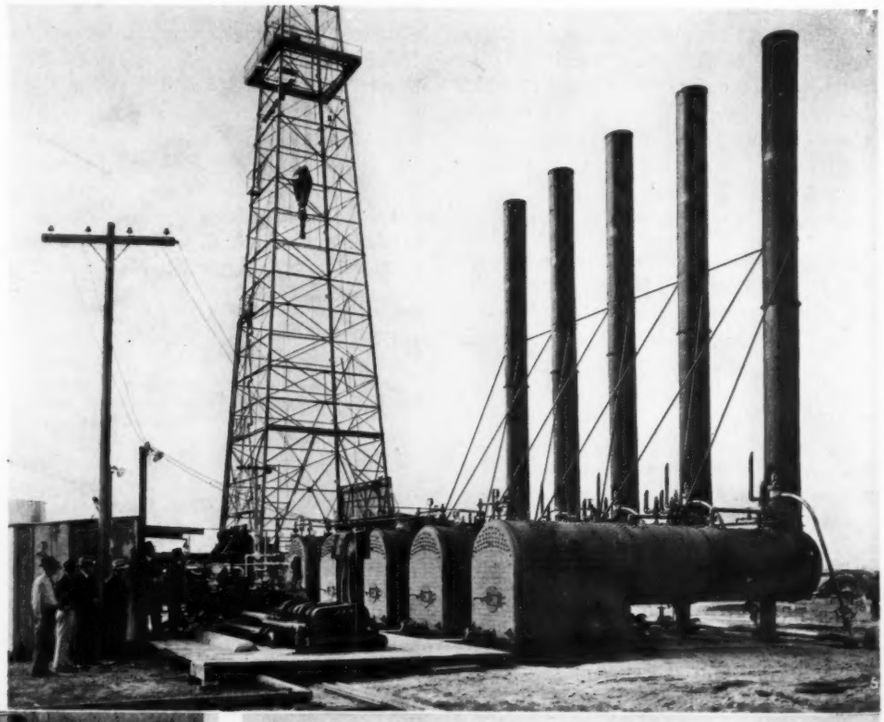
Netherland-Belgian interests recently abandoned attempts to discover oil at Cuarny, near Yvardon in the canton of Vaud, Switzerland, after drilling to some 6,580 ft. without satisfactory indications of oil or gas. Further tests are to be sunk at Servion and Eclepens in the canton of Waadt, where there are indications of oil.

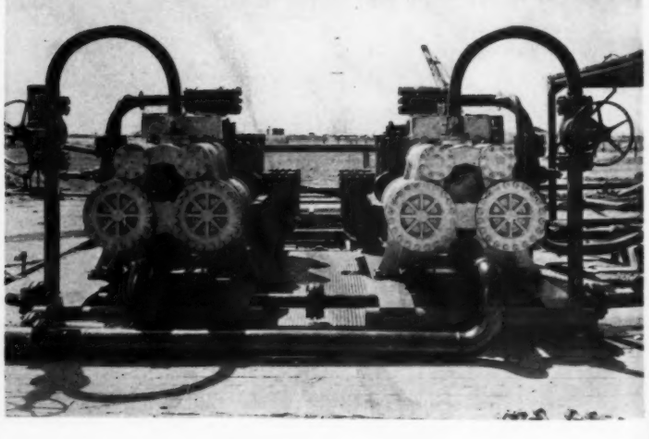
Production of oil is at present confined to the Selince district on the island of Mur, where the output has steadily increased from 960 bbl. in 1936 to 3,690 bbl. in 1938 and about 7,900 bbl. in 1938. Output of natural gas is about 2,000,000 cu. m. annually. Socony-Vacuum has applied for an exploration concession in Jugoslavia.

Encouraged by reports of petroleum exploration at Harte, near Kolding, in Denmark, the Swedish government has become interested in the possibilities of the Scania district, south Sweden, where geological research has been carried out for some time. Dr. Joseph Eklund, who is in charge of the investigations, stated recently that promising strata have been located at Soderslatt, between Ystad and Skanor, while an oil exploration concession has already been granted to Skanska Cement Aktiebolaget over Hejnum, Othem and Tingstade, on the island of Gotland.

Danish American Exploration Company, subsidiary of Gulf Oil Corporation, has two gravimeter parties active which have already explored about a third of Denmark. A seismograph outfit has been added to check on promising results, and core drilling is about to begin for further geological information. No commercial test will be made during 1939.

Dr. A. Rosenkrantz, Danish geologist who recently conducted an expedition to west Greenland, has announced that he made discoveries of oil in the peninsula of Nugssuak. He had located a large mud volcano near Avfarsuak, which erupted highly oliferous material. Strata formation is practically identical with that of the Texas oilfields. Further investigations will be carried out during the current year under the auspices of the Danish Colonial Office, from which a report is expected in the autumn.





Modern American drilling practice as demonstrated by the super rig installed on Superior Oil Company's Moody No. 1 at Rio Bravo, California where 7000 ft. of hole was made in eight days including time for setting 13⅜ in. casing. The boilers developed 135 h.p. and 500 lbs. working pressure, highest ever used for drilling. The pumps, 15½ in. by 9¼ in. by 22 in. used with 3,500 lb. working pressure are larger than any previously made.

IMPORTANT PERUVIAN Area Opened by Aguas Calientes No. 1-A

By J. E. Brantly

Ganso Azul's 2,500 Bbl. per Day Producer in Eastern Peru Indicates Important New Reserve—Crude May Reach World Market Soon.

THE COMPANIA de Petroleo Ganso Azul, Ltda., on February 26 of this year, completed its Aguas Calientes No. 1-A well in eastern Peru, for approximately 2500 bbl. daily of 45 deg. gravity A.P.I. oil, through full open three inch tubing. On ½ in. choke the well flowed 750 bbl. daily for several days and on 40/64 choke it produced approximately 1000 bbl. in 24 hours. After 14 days of testing the well was closed in because of lack of storage and transportation facilities.

The Aguas Calientes structure on which the well was drilled is located about 400 miles, or 715 kilometers, north 35 deg. east of the city of Lima, Peru, and lies approximately 75 deg. west of Greenwich and nine degrees south of the Equator. The Brazilian border at its nearest point is 70 miles to the northeast. The total area of the concession is about 90,000 acres with the long dimension of the property extending northwest-southeast, parallel to the general strike of the Andes Mountain system. The Rio Pachitea, some 15 miles above its mouth in the Rio Ucayali, cuts the concession in its southeastern part.

The concession proper varies in elevation from an estimated 1200 ft. above sea level on the river to 1800 ft. above sea level at the highest point and is extremely hilly and rugged. The topography in broad aspect reflects the contour of the structure itself. The broad, flat first bottom and flood plain basin of the Amazon drainage system extends for hundreds of miles to the northward and eastward of the Aguas Calientes structure and concession. A few miles to the west and south the low foothill ridges and ranges of the Andean Mountain system begin, increasing rapidly in elevation until the snow-capped ranges of the Cordillera Blanca are reached at 20,000 ft. above the sea and 200 miles distant from the concession. Thus, on the Aguas Calientes concession the easternmost foothills of the Andes definitely meet the broad, flat lands of the Amazon basin. From the crow's nest of the derrick there may be seen to the eastward, and on Brazilian territory, several sharp peaks and a small range of relatively low mountains. These isolated features stand out in bold relief above the flat jungle country. These mountains appear to be of igneous origin from a distance but may be structural.

The principal drainage on the concession proper is northeasterly into the Ucayali and thence northerly to the Rio Maranon. The Rio Pachitea heads in the snow-fed lakes of the Andean plateau to the southwestward, though most of its water originates in the foothills on the eastern flanks of the Andes where the rainfall is extremely heavy for eight or nine months of the year. This annual rainfall is estimated to be somewhat in excess of 100 in. practically all of which falls in the eight months' period from early October to late May. Rio Pachitea at Aguas Calientes is about the width of the Ohio River at Louisville and has eight or nine feet of water across the bars during the dry season. The Ucayali, below its junction with the Pachitea, approximates the size of the Mississippi River at St. Louis and has a minimum of 12 ft. of water below Pucallpa. These enormous tributary streams, literally thousands of miles from the mouth of the Amazon, explain the magnitude of that great stream in its lower reaches.

From the low frontal ranges of the Andes, including the immediate vicinity of Aguas Calientes, eastward to the Atlantic Ocean, there is a dense tropical jungle of heavy bodied trees which attain heights of 150 ft. or more. Massive lianas or vines, as large as a man's body, reach from the ground to the high boughs where orchids and air plants grow in luxuriant riot. These jungle forests do not conform to the usual adventure story understanding of the term jungle, for the dense overhead growth prevents the penetration of the sunlight to the ground and hence only those few plants, mostly ferns, brackens and mosses, which find humid shade a congenial environment can exist. The floor of the jungle is clean and one is quite unhampered when walking over it. Along the edges of streams and rivers and of the occasional areas bare of vegetation, where the sun may penetrate, there is however a border of dense impenetrable growths of trees, vines and shrubs. This border is rarely penetrated by our explorers, and hence the erroneous ideas. The trees are principally hardwoods such as mahogany, ebony, green heart, cedro and many others, but also a number of varieties of rubber and other gum trees, and the lighter and softer woods such as balsa and ceiba, which latter is one of the commercial sources of the fibre kapock. There are also many varieties of both usual and exotic palms, several of which are quite useful as structural material. The hardwoods supplied fuel for the drilling of wells No. 1 and No. 1-A, and also heavy and light timber for rig and building construction. The soil, despite the abundant vegetation that it supports, is relatively poor and a vegetable garden was grown with difficulty. This is undoubtedly due to lack of plant food in the sandy source materials of the soil and the leaching action of the abundant rains.

Located as the Concession is, only nine degrees south of the Equator, and at a relatively low elevation, it is necessarily

The sun rises over eastern Peru silhouetting the derrick of Aguas Calientes No. 1.

River steamer Alberto on the Rio Ucayali approaching the mouth of the Pachitea.

warm. The seasons are poorly defined in temperature changes and in consequence are considered by the natives to be based on rainfall. From the first of October to the first of January is a period of fairly heavy precipitation, with temperatures ranging probably never above 90 deg. F. From the first of January to the first of April the rains continue, though the temperature in the middle of the day may be somewhat more than in the earlier season. The heaviest rains of the year usually fall during these months, particularly January. From the first of April to the first of June the rains continue with a probable maximum temperature not exceeding 90 deg. From June 1 to October 1 there is comparatively little rain and the temperatures remain about the same. At night the temperatures may go to 65 deg. or 70 deg. On the whole and for tropical country the climate is both pleasant and salubrious. The tradewinds, which blow from a direction slightly south of east, are largely responsible for the moderate temperatures as well as the heavy rainfall against the eastern flank of the Andes.

The region, for all practical purposes, is virgin in so far as human habitation is concerned; therefore, there are none of the usual diseases found in tropical countries. With two hundred natives and Americans in camp, the Company doctor had surprisingly little to do. With proper drainage and other sanitary precautions and a properly constructed camp, the Aguas Calientes hills are as healthy as most any other normal locality either in the tropics or outside.

The country along the Pachitea and Ucayali Rivers is populated very sparingly by a people who are descended principally from Spanish and Portuguese fathers and Indian mothers, but there is also an admixture of various other nationals who came into the country during the great rubber boom of early 1900. The laborers for the work on the Concession were recruited from villages up the Ucayali and Pachitea Rivers and down the Ucayali. The nearest village to the south, up the river, is a hundred miles or more distant. The village of Masisea is about 75 kilometers down stream from the Concession and Pucallpa is another 80 kilometers by river, though only 43 kilometers or 27 miles in a straight line. These villages have populations of about 300 and 600 people respectively. The population at other points along the river consists of a few Peruvians living in scattered one-house ranches and a few semi-civilized Indians. The jungles along and away from the river are populated very sparsely by an entirely uncivilized though harmless group of gee-string Indians. The natives of mixed blood, though quite small in stature, make excellent common laborers and develop into satisfactory rig helpers, automobile and tractor drivers. There is little education among them, but a few are capable of reading and writing. Within a reasonable distance of Aguas Calientes there is adequate labor available to operate a property of considerable size.

Equipment for the development work on Aguas Calientes was shipped to Para and there transshipped on the river-going steamers and prow type lighters or *alvarengas*. From Para the cargo was conveyed up the Amazon River to the junction of the Rio Solimoes and Rio Negro which, together, form the Amazon, thence up the Solimoes to the junction of the Rio Maranon and the Rio Ucayali, which two streams form the Solimoes, thence up the Ucayali to the mouth of the Rio Pachitea and up the Pachitea a distance of 20 kilometers to the river port of Aguas Calientes. The entire distance traveled by river is somewhat less than 3000 miles or 5000 kilometers. From the river port of Aguas Calientes a jungle road was cut and built into the location, a distance of about six miles or ten kilometers, to travel a straight line distance of two miles. All equipment was handled from the port to the Concession by Caterpillar tractors and wagons. Light trucks were used for moving men and light material and supplies.

Personnel was moved from America to Lima by air or ship, thence to San Ramon on the eastern flank of the Andes by automobile, thence by land plane to Pucallpa where a transfer was made to a pontoon plane for the remaining 30 miles to the Concession river port. The airplane service from San Ramon is that established and operated by the government for transport-

A landing ramp for the all important airplanes and an airview of the Ganso Azul camp at Aguas Calientes, Peru.

Native workman cleaning up around the completed fire boxes which burned wood for fuel in the jungle operations of Ganso Azul.

ing mail and passengers to Iquitos. It is a part of the Peruvian Air Service and is under the direction of an American Naval Aviation officer.

The time required from New York to the Concession by water is approximately 60 days with good connections. From Los Angeles to Lima by air is 4½ days and from New York three days. One day is usually required in Lima to arrange for the necessary entrance papers and cedulas, one day to travel by automobile to San Ramon and another day to reach the Concession. Thus, the over-all time from Los Angeles is about eight days and six from New York. From the Concession to Lima the trip may be made in 12 hours during good weather. The government is said to have purchased amphibian planes to fly from San Ramon to Iquitos. After service is established with these ships, the trip to and from the Concession from Lima may be made much more readily and comfortably. The present stopover in Pucallpa is frequently several days in bad weather and the facilities for a comfortable sojourn are entirely lacking.

For telegraphic communication Ganso Azul maintains a short wave radio station at the Concession which handles all messages to and from Lima, from which point they are forwarded to the United States. The service is such that the reply to a night letter will be in the office in Los Angeles by nine o'clock the following morning. In other words, a fifteen hour reply to a night letter. This is occasioned largely by the fact that Lima time is three hours ahead of Los Angeles time.

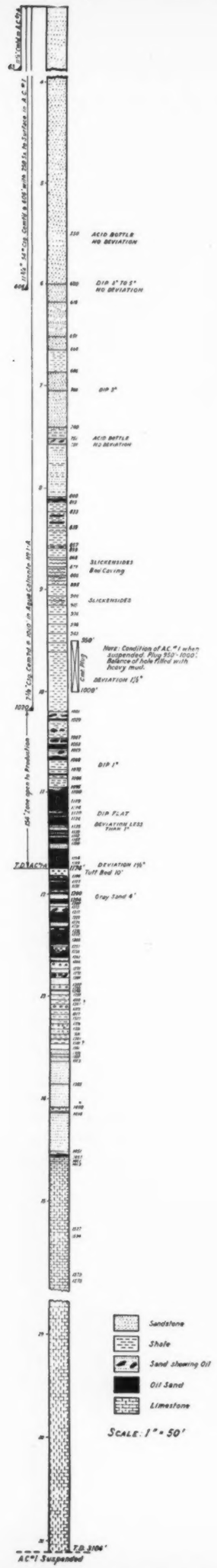
The Aguas Calientes Concession lies in that great, elongated, narrow geosyncline extending from the Island of Trinidad in a westerly direction across Venezuela to Colombia, thence southwesterly into Ecuador and northern Peru, southeasterly into Bolivia and finally in a southerly direction into Argentina and Paraguay. The original sediments were all derived from the old Brazilian Land Shield and possibly to some extent from an old land area off the present north coast of South America now evidenced by northern Trinidad, the Island of Margarita, the northern part of the Goajira Peninsula, until recently an island, and other islands of the lesser Antilles. The Brazilian Land Shield is largely responsible however for all of the sediments which include practically the entire existing land areas north, west and south of the Shield. The sediments range in age from lower Paleozoic into upper Tertiary. In the immediate vicinity of Aguas Calientes the formations are all of the Mesozoic Era with possible imestones of the Permian. The sequence of formations as determined by Fyfe are:

Age	Formation	Thickness
Tertiary and Upper Cretaceous	Red Bed Series consisting of reddish sandstones and shales with a 450 ft. sandstone at the base called Sugar Sandstone. Present around the edge and off the flanks of the Aguas Calientes structure.	5000 ft.
Middle Cretaceous	Chonta-limestone-marl Series composed of fossiliferous limestones, shales and some sandstones. Present on the anticline.	2000 ft.
Lower Cretaceous	Aguas Calientes Sandstone. Sandstones, grits, conglomerates, shales and volcanic ash beds. Present in a narrow belt along the crest of the Aguas Calientes fold. Thickness about 2000 ft. on fold.	4500-5000 ft.
Jurassic (?)	Lower Limestone. Encountered at 1457 and penetrated to 3104 in Well No. 1. Very hard blue-gray limestone with much chert.	

The Sugar Sandstone occurs as a sharply defined ridge standing some 300 to 500 ft. above the river level and encircling the entire structure. Beneath this is the Chonta limestone series, named for Chonta Island and anticline in the southeastern end of the Concession, which covers the entire structure between the Sugar Sandstone rim and a narrow strip along the crest of the anticline where the Aguas Calientes sandstones outcrop. The No. 1 well proves the presence of 1450 ft. of the Aguas Calientes sandstones below the surface at the location, with an additional thickness of a few hundred feet on top and on the flanks of the fold. Thus, some 3000 to 3500 ft. of this sandstone series is missing. That remaining over the structure consists of silts, sandstones, grits and conglomerates to a depth of about 900 ft., dark gray shales to 1020 ft. and predominating sandstones with thin shale and volcanic ash beds to 1457 ft., where the limestone was encountered. This material is similar in appearance to and apparently in the same stratigraphic position as the basal Comanchean grits and conglomerates of Venezuela and Colombia.

The structure is a slightly assymetric anticline with an axial direction approximating northwest-southeast. The structure is quite flat on top with dips on the flanks rarely exceeding 20 or 25 deg. The nature of the formations and the rugged, stream cut topography render exposures of strata in place abundant, thus enabling the geologists to do the original local geological work in some detail. The structure is estimated by Moran and Fyfe to be approximately 15 miles long in the northwest-southeast direction and about nine miles wide. They further estimate the closure at some 3500 ft. These dimensions are undoubtedly reasonably accurate, though it may not be expected that the productive horizons will cover more than a small part of the entire area of the feature. This anticline is the last basinward fold of the Andean Cordillera and is parallel to the primary axial directions. The Chonta anticline on the southeast end of the Concession is much smaller than the Aguas Calientes fold, probably 1500 ft. lower stratigraphically, and apparently separated from the larger fold by a fault.

The oil is quite evidently not indigenous



Composite log of Ganso Azul's Aguas Calientes No. 1 which suspended drilling February 2, 1939 and No. 1-A which was successfully completed on February 26, 1939.

to the coarse sands and grits in which it is found; these materials appear to be of either fresh or very shallow marine water origin. The Lower Limestone (Jurassic?) may be a source bed, having that appearance, and also having seepages in it along the Andes Mountain front. Also there are great thicknesses of dark colored shales of undetermined age, apparently lying below this limestone, which are exposed in the frontal mountain ranges. The Chonta Series may also account for some oil. The structural features are such that migration might have occurred either laterally or vertically, assuming faulting between the Aguas Calientes and Chonta anticlines. Also, though not reported, it is quite possible that the very highly petroliferous Cretaceous and possibly Comanchean formations of the Orinoco Basin of Venezuela and Colombia extend this far southward along the synclinorium. The Jurassic of southern Bolivia and western Argentina is reported to be a source of oil locally.

Numerous seepages occur in the mountains to the west and south of Aguas Calientes as reported by Moran, Fyfe and Greene; others are known to exist both northwest and southeast of the structure along the flanks of the outer system of the Andean folding, especially near the Pongo de Manseriche on the Rio Maranon, about 300 miles northwest of Aguas Calientes and in the same stragigraphic horizons. They occur in the Lower Limestone and the Aguas Calientes sandstone of the foregoing geologic section.

Some ten years ago Robert F. Moran, a consulting geologist of Los Angeles, California, was in the Peruvian Montana, or jungle country, for the Peruvian Government investigating the feasibility of building a railroad to the Rio Ucayali from the plateau country. In flying out from Iquitos to San Ramon, he noticed from the air that the fartherest basinward ridge of the Andean system was a clearly defined anticline. This was readily determinable by the corona of the Sugar Sandstone and its dip slopes outward from the core of the structure. Also other dip slopes on the Chonta limestone were seen nearer the axis. Moran thereupon investigated the structure, acquired a concession on it and sent in Douglas Fyfe to study the feature. After several years of field work, which could only be done during the dry seasons, a group of Los Angeles capitalists, headed by Wm. C. McDuffie as President, organized a company for the development of the property. Drilling and Exploration Company, Inc., was selected to conduct the drilling operations.

The river port, the road and the location having been prepared by Bart Gillespie, equipment was assembled and shipped from New York on October 12, 1937. Approximately 750 tons by weight (1000 dimensional tons) were exported. At the port of Belem in the State of Para, Brazil, the cargo was transshipped to one river steamer and four prow-type lighters. The ship carried some 400 tons and the lighters the remainder. On November 28, 1937, after the ship and its tow had left the mouth of the Rio Negro and the city of Manaos by some eight hours, it put into shore to take on wood, which is used for fuel on the river boats. When within 50 ft. of land the ship ran onto a submerged stump or log, which resulted in the piercing of the hull in the engine room. The ship thereupon sank slowly in some 20 ft. of water and the lighters were cut loose and towed into Manaos. The stranded ship was a day from cable connection and 15 days from the nearest salvage ship. After some weeks of discussions by cable, salvage operations were finally commenced the middle of January, 1938. During this period the river had been rising. After several weeks of salvage work and the recovery of about 125 tons of cargo, the river entirely covered the ship and salvage ceased. The equipment recovered and the lighters were then moved up the river to Iquitos, complete inventories taken and replacement equipment ordered. The last cargo reached Aguas Calientes June 25, 1938, and the No. 1 well was spudded on July 4. The Drilling and Exploration Company, Inc., crew consisted of E. D. Van Marter in charge of transportation; Claud E. Kelley, head driller; H. E. Johnson, driller; D. B. Grable, driller; C. L. Tidwell, welder, mechanic and extra driller, and R. D. Evans in charge of pumps and mud supply, and extra driller. Douglas Fyfe represented Ganso Azul, as geologist.

A thorough analysis was made of all the problems controlling transportation, supplies, labor and other factors that might affect the operation. It was concluded that steam drilling equipment of the simplest type would be best suited to the job. For this purpose there were shipped to the Concession four 250 lb. 125 H.P. boilers and a 14-7¼-18 mud service pump and a smaller mud mixing pump and a 11 by 11 hoisting engine with a duplicate for replacement and also to operate the wire line coring tools, a drawworks having a seven inch drum shaft, 150 ton hook, traveling block and crown block, 6000 ft. of 5 $\frac{5}{16}$ in. drill pipe, 2000 ft. of 4½ in. drill pipe and 6000 ft. of 3½ in. integral joint drill pipe to be used also as tubing. A full and com-

plete list of repair parts, pipe and fittings and consumable supplies for a four to six month period were likewise shipped in.

The drilling program called for the setting of 600 ft. of 11¾ in. casing in a 16 in. hole with a 10⅝ in. hole to follow on down. Six thousand feet of 7⅝ in. casing and 500 ft. of perforated liner and high pressure Christmas tree valves completed the well equipment program. These casing sizes were selected as being sufficiently large to permit any desired drilling depth with adequate coring and testing. Formation testers of the conventional type were used in rat holes drilled with 8½ in. wire line and conventional core barrels.

Bearing in mind the mountains to the west and south and the possibility of a high hydrostatic head, all precautions were taken at the well head against possible blowouts.

The selection of steam as the source of power necessitated the use of wood as fuel. Fortunately the jungles abounded in hardwood of exceptionally high heat value. The average boiler consumption was about five cords daily, which developed slightly less than the rated horsepower capacity of the boilers. As the location and camp sites were cleared much timber suitable for fuel was felled, cut, split and racked near the boiler site. As the work progressed and the fuel supply was farther and farther away from the rig, an overhead wire cable or skyline that had been sent down for the purpose was erected. This line was a used 2500 ft. drilling line that had served a useful life on a Kettleman Hills well. Old sandline, likewise shipped in for the purpose, was attached to specially built trolleys and operated by a two-drum hoisting winch. Trees were felled in the jungle, hauled to the boiler plant where they were cut in four foot lengths by a battery of four power saws and then split and racked at the boilers.

In order to supply a sufficient combustion chamber for the wood fuel, the boilers were set 42 in. above the ground and a firebox built down to the ground and extending 48 in. out from the boilers. It had been expected that steam and the fuel supply would be a source of considerable trouble, but with the preparation and the character of wood no difficulty whatsoever was experienced at any time except, at the latter part of the Christmas holidays, when all the woodcutters insisted on going to their homes, the wood supply fell short for a day or two.

Of the five pounds of food allowed each American each day, three and one-half pounds was shipped in from the States and the remaining one and one-half pounds was obtained locally in the form of cooking bananas, vegetables, beef, fowl, eggs, game and fish. A garden for vegetables was likewise cultivated for food supply, but unfortunately the soils are not fertile and vegetables in consequence do not grow luxuriantly. Probably with better selection of soil, garden truck can be grown satisfactorily. Fresh food is extremely important under such conditions.

Well No. 1 was spudded July 4, 1938, and drilled to 615 ft., where 11¾ in. casing was set. Operations were then suspended for a period of several months. Upon resumption of drilling an oil showing was encountered at 751 ft., at which point coring was commenced and continued into the limestone. The hole was cored in 8¼ in. size, tested and reamed. The last oil sand was found at 1281 ft. with the exception of a few feet at 1455. An oil bearing section 240 ft. in thickness was encountered from 1021 to 1261. Approximately 150 ft. of this section is clean oil sand with 90 ft. of shale and volcanic ash breaks scattered through. Both the porosity and permeability are satisfactory. At 1457 ft. a hard limestone was encountered. The hole was drilled to 3104 ft. and temporarily abandoned, but preserved for possible future deepening, with a cement plug placed from 900 to 1000 ft. The derrick was skidded 24 ft. south and Well No. 1-A was spudded February 14 and completed February 26 at a depth of 1174 ft. Sixty-three feet of 11¾ in. casing was set, a 10⅝ in. hole drilled to 1174 to the top of a volcanic ash bed, 7⅝ in. casing set and cemented at 1020 ft., the Christmas tree installed, 3½ in. drill pipe run as tubing, and the well swabbed into production.

The locality name Aguas Calientes, which means hot waters, is derived from two hot water streams and many hot springs. The hot waters are highly mineralized and the local indians and natives have established their spas (?) where they enjoy the healthful baths. At least they seem to think so. As the No. 1 well was drilled it was noticed that at 150 ft. the circulating mud was much warmer than might have been expected. This temperature increased rather rapidly to 800 or 900 ft. in depth and then remained fairly constant until the hole was completed. The oil is also unusually warm. Several explanations have been offered for this high temperature, the most logical one being, probably, that the area is in a particularly warm region of crustal rocks due to the unusual closeness of hot rock bodies below the surface.

The well is capable of producing 2500 bbl. daily of 45 gravity oil through the tubing and undoubtedly a much larger quantity through the open casing. There is very little gas with the oil and every evidence that the pressure is derived from a hydrostatic head to the southwestward. The quantity of recoverable oil proved by the single well is as yet indeterminate, but at least it is very substantial.

Transportation facilities would require a 28 mile pipeline to the port of Pucallpa on the Ucayali River, thence to Iquitos or Manaos by lighter and thence down the river by sea-going tanker or by lighter, depending upon the location of the refineries using the oil. Ships of any draft can reach a point some 1500 miles or more up the Amazon River from Para and ships of 25 ft. draft can go as far as Iquitos at all seasons of the year. From Iquitos to Pucallpa, the probable terminus of the pipeline, the minimum water is 12 ft. during the dry season. From Pucallpa to Aguas Calientes the minimum water is nine feet except some years during August and September, when it may be a foot or two less. The distance of the Concession from the sea and its isolation suggest great difficulties in operating the property, but such is not the case, for the great Amazon River system affords water adequate to permit efficient and economical transportation.

Bunkhouse at the Aguas Calientes camp and a load of fuel transported to the rig to carry on drilling operations.

NATIONALIZATION Delays Development of Encouraging Brazilian Indications

By D. M. Veysey

Successful Completion of Small Producer in Lobato, Brazil, Stimulates Interest—Restrictive Laws Check Rapid Development by Excluding Foreign Capital—Expropriation Measures Not Contemplated.

Cia. Itatig, first company to drill under the petroleum laws of Brazil's New Regime, building Sergipe No. 1.

As early as 1891, an English company discovered petroleum in Brazil, near Bahia (Sao Salvador). Brazil was then an infant republic. Labor problems caused by the recent abolition of slavery absorbed attention in the great cocoa port, and so the finding of a new natural resource for which no special need could be seen at the time, failed to arouse interest.

Explorations undertaken in the meantime by federal and state departments, by international oil companies, and by individuals, have been carried out in various quarters of the country, but attention has gravitated back to Brazil's only seep, at Lobato, in the Reconcavo da Bahia, (Bahia Concavity, or inner basin from which the sea has retired).

On January 22, 1939, on a Lobato concession granted to the Brazilian Navy, after engineers of the Ministry of Agriculture had drilled 682 ft. through granite, oil gushed 98 ft. above ground for a short time, until pressure was lost. The National Petroleum Service, who are now closely supervising activities in Lobato, are examining specimens of the gas for helium content. Tests report that the oil, of which about half a barrel is being produced per day, is of low density, producing 15 percent of gasoline at the first distillation.

In the extensive economic plan, to cover at least five years, scheduled to begin this year, the government should, according to the President, encourage the development of all mineral resources for the export market, to assist in balancing foreign trade. On the other hand, efforts would be made to limit the importation of raw materials, while encouraging the purchase of manufactured machinery which would help develop the country's basic industries.

"Not that we desire to create obstacles to world commerce," explains the report, "nor to establish an economic autarchy but we must avoid the dangers of becoming merely a producer of raw materials. Every agricultural country sells its products cheap, and pays high prices for what it consumes."

The natural conclusions drawn from correlating the above statements are that the time has arrived in the economic history of Brazil when the long-mooted question of petroleum resources will receive resolute attention; that the industrial advance, as well as other features of the Five Year Plan, will increase consumption of petroleum products: that establishment in Brazil of a field that would make her independent of oil imports might alone readjust the unfavorable trade balance.

April 29, 1938, the supply of national petroleum was declared a public utility, the "supply of national petroleum" being understood to mean the production, importation, transportation, distribution, and commerce of crude petroleum and its derivatives, as well as the refining of imported or national petroleum, whatever its origin or extraction may be. The federal government claims the sole right to authorize, regulate, and control all phases of the industry, including pipeline construction, the installation and localization of all refineries or deposits, decision on the production capacity of refineries, the nature and quality of the products refined, and fixing of prices of refined products, whenever possible to be uniform throughout the country.

A National Petroleum Council was created, an autonomous body, all native-born Brazilians, appointed by and directly subordinated to the President, to execute the measures of the nationalization decree. Since last September the following have served: President of the Council, General Horta Barbosa, (representing the Ministry of Finance); Vice-President, Prof. Domingos Fleury da Rocha, (Ministry of Agriculture); Engineer Alaor Prata Soares, (Industrial organizations); Major Joao Waldetaro Amorim de Melo, (Ministry of War); Capt. Helvecio Coelho Rodrigues, (Ministry of Marine); Dr. Eurico Delamare São Paulo (Ministry of Public Works); Prof. Ernseto Lopes da Fonseca Costa (Ministry of Labor, Industry, and Commerce); Dr. João Daudt de Oliveira (representing commercial organizations).

To defray expenses arising from the execution of this decree-law, a tax of about 15 cents per ton will be levied on all petroleum products, of whatever origin, handled in the national territory.

In the nationalization acts, stress was

laid on petroleum as an indispensable item of national defense. As such it still claims the particular attention of both army and navy. Before the creation of the National Petroleum Council, all oil matters affecting either were referred to the mineralogical departments of the Ministry of War or of the Ministry of Marine. All other aspects were handled by the Ministry of Agriculture, through its National Department of Mineral Production, with subdivision, the Service for Development of Mineral Production. These bodies still function, with their powers not specifically revoked. It is supposed that new laws will correct overlapping. So continuous is legislation that the position as regards petroleum alters almost from week to week.

Since the National Petroleum Council was named, the issue of information, verbal or printed, on the subject of petroleum in Brazil has been banned, violation being considered equivalent to contempt of court.

Most notable of the government publications withdrawn is the very recent Bulletin 23, "The Petroleum Situation in Brazil, 1938," by Dr. Avelino Ignacio de Oliveira, Director of the Service for the Development of Mineral Production. In this capacity, the author, who is a mining engineer and an experienced topographer, has been chosen to assist the National Petroleum Council.

Discussing actual exploration, Dr. Oliveira stresses the urgency of a much larger appropriation to buy modern drilling equipment and better apparatus for the geophysical corps, and to pay for training Brazilian geologists in methods of oil production and extraction. Such a technical corps must be prepared as soon as possible, he brings out.

The stumbling block in Brazil's petroleum progress is financial, more than anything else. Dr. Oliveira's statement, "In South America we unquestionably occupy an outstanding position in geological studies," is supported by the excellence and popularity of the course at Ouro Preto School of Mines, in the State of Minas Geraes. For Brazilian petroleum geologists are mining engineers. But oilfield practice is wanting. The author suggests that engineers selected from those who have already served in oil exploration work in Brazil could acquire the knowledge in two years' study abroad.

Again, the enormous Brazilian terrain, with its dearth of superficial indications, requires the most up-to-date methods of exploration. But double the amount of the maximum appropriation (reached in 1937) would not cover the cost of one modern rig for deep drilling. So far, the greatest depth attained in Brazilian drilling was 5,123 ft., with a final diameter of four inches (at Bore Hole No. 2 of the Cia. Petrolifera Brasileira, S. A., near S. Pedro, São Paulo, Dec. 1937). Drilling equipment belonged to the Ministry of Agriculture, from whom much of the equipment used by exploration companies is borrowed. Old artesian well derricks frequently have been used, and 2,000 ft. is much nearer the average depth bored than the figure just quoted. Thus, although it is 20 years since the government first undertook or assisted petroleum exploration work, nothing outstanding has yet been accomplished.

Brazilian flag, symbol of nationalization, unfurled atop the Itatig rig No. 1 to mark completion of the derrick.

Now that the search appears to be intensified, private concessionaires, in some cases more adequately financed than heretofore, have been planning to drill in Lobato. But on February 8, a government decree reserved the Lobato district "against prospecting and exploiting by private individuals."

Early in March the National Petroleum Council heard the petition of citizens Sylvio Froes Abreu and Carlos de Avila Pires, who had obtained rights to prospect in said territory by executive decree in 1937. The Council decided that these rights had not been annulled, but that, since permission had not been granted to exploit the natural resources, the petitioners could only continue their search for petroleum, but could not claim any when found. They stated that the government act forbidding private initiative in the Bahia Concavity, was based "on the interests of the nation, which, in this case, over-ride the individual's, inasmuch as the extent of the oil deposit may no more than attend to the needs of national defense. Conditions of a technical nature would indicate single plan and direction to avoid spoilage of the oilfield."

Whether this is a modest view of Lobato potentialities may soon be determined. Some geologists consider that the Lobato strike is on the fringe of a productive area. It is believed that the dome of the anticline occurs some 12 miles south of the present well, and there is evidence of a double fault near the dome. Naturally, unless some sort of profit can be guaranteed to private concessionaires, drilling will be left to the government, who now propose obtaining cores of all drillings.

Let us take a brief glimpse at Brazil's petroleum legislation:—Concessions consist of units of 2,000 hectares (4,942 acres). A maximum of ten will be granted, to native-born Brazilians only. No one is eligible for more than two different authorizations, simultaneous or successive, in a proven zone, i.e., within a radius of 50 miles from a producing well; or to more than five authorizations in an unproven zone.

Three years are allowed for exploration, during which legitimate work must be carried out, confidential reports, cores, etc. submitted to the government, and at least one test of not less than 2,000 ft. must be drilled. Unless prevented by forces beyond control, the concessionaire must fulfill these obligations or accept cancellation.

Drilling will be government authorized from all the technical data at its command, to insure against prejudicing the capacity of other wells. Wells must be capped until government inspection is made. Production from only one well will be prohibited, unless the government can see reasons to the contrary.

The monthly output of each well must be reported to the government, who will determine its maximum production. The government will receive a royalty of nine percent of production, in cash or in kind, but in the case of hydrocarbon gas, no levy is to be made on that used for repressuring the well. If payment is made in crudes, the concessionaire is responsible for delivering or storing it at the government's behest.

If public interests warrant, a conces-

sionaire who has built pipelines must also transport crude from neighboring concessions.

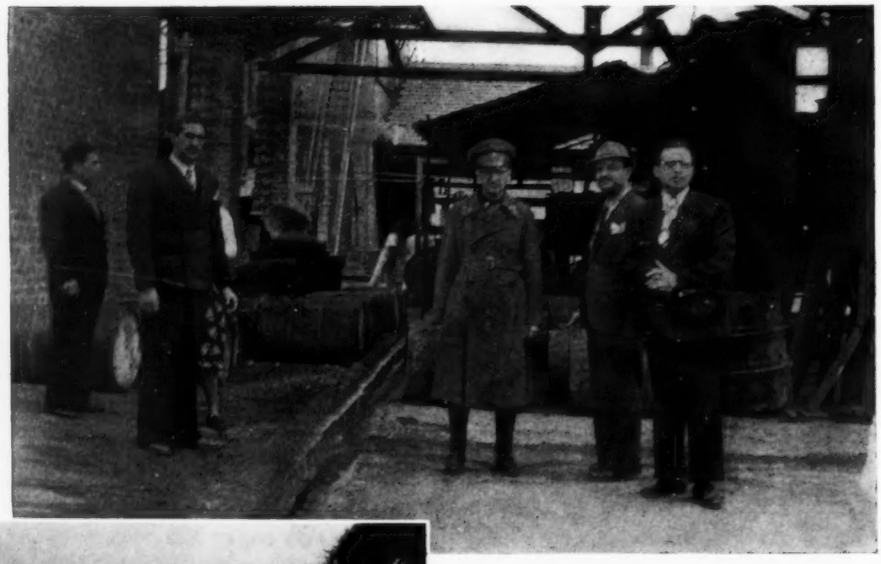
The government will determine whether the crudes shall be exported or refined in the country. The federal government may have its petroleum distilled at the concessionaire's refinery at cost price plus five percent. No refinery for the distillation of imported petroleum can be installed in the country without previous authority from the federal government and a hearing of fiscal and military technicians.

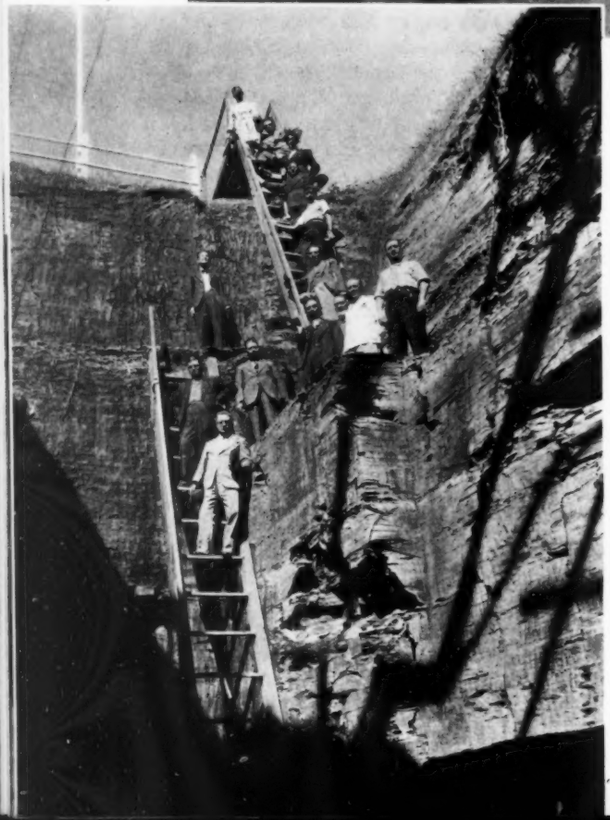
All administration and financial acts, and balance sheets must be open to and approved by the government Fiscal, under penalty of cancellation of the concession. The government can rescind production rights, indemnifying on capital actually invested and on net profits during the last five years, taking into consideration the degree of drainage of the well, or its probable duration.

Ever hopeful of the discovery of helium in the national territory, the government declares this and other rare gases a national reserve, and will pay the concessionaire the cost of separation of such gases, or, in the case of pure helium, will buy the well at 15 percent above cost.

No concessions for prospecting or producing, and no installation of refinery machinery are allowed within 93 miles of the frontier, without approval of the Superior Council of National Defense.

The present state of the petroleum industry in Brazil is not drastically disturbed, as has been the case in countries where nationalization is an after-thought. Expropriation measures are not anticipated, and no considerable part of the $33,000,000 direct investment of American capital, represented by the four American importation and distribution companies, has been affected. It is the refining business which came up specifically in the nationalization laws.





Chief of the Brazilian army in uniform and Gen. Horta Barbosa on his left (with hat) visiting the Panal oil shale refinery. Gen. Barbosa is president of the National Petroleum Council which controls all aspects of Brazil's oil activities. Left, Panal's oil shale quarry which commences about a yard below the surface and extends below 800 ft.

So that earnings derived from this business will stay in Brazil, the capital stock of companies refining petroleum in Brazil must be in common denominative shares owned entirely by Brazilian nationals. A foreign wife renders a native-born Brazilian ineligible to shares, for by law half of his property belongs to his wife. But a native Brazilian woman married to a naturalized Brazilian may own shares.

Direction and management must be in the hands of native Brazilians. The proportion of Brazilian employees to foreign must continue to conform with the two-thirds law, a general employment measure effective for the last couple of years. In every department, out of three employees, two must be Brazilian; out of two, one must be Brazilian; if only one, he may be foreign.

Six months, with an extension of sixty days, was granted for the refineries to fall in line with the above measures. The following refineries have opened up in Brazil during the last eight years: the Refinaría Mattarazzo, a Sao Paulo plant handling Ecuadorian crudes, which is now up for reconstruction and revision, and the Cía. de Refinaría Ypiranga, in Río Grande do Sul. The former is entirely Brazilian; the latter sufficiently so as to require little readjustment. What would have been Brazil's largest refinery, completed by the Standard of Brazil in Sao Paulo, May 1937, was never opened. This would have been the first entirely international refinery in the country, and is a topping plant, designed to run 2,500 bbl. per day of Venezuelan crude.

Two refinery enterprises are pending. The State of Río de Janeiro has received permission to build a 4,000 bbl. per day refinery, for which a state appropriation of $2,000,000 has been passed.

On February 25, Brazil signed a treaty with Bolivia to provide railroad connection into the Bolivian oilfields, in order to take Bolivian crudes, for which the government will build a new refinery on the Brazilian railway network, near Sao Paulo city.

Brazil may also in time participate in handling crudes from Peru's Andean reserves, for this product will find a natural outlet down the Amazon through the port of Para (Belem) (Article page 77). Possibilities of Brazil's establishing an oilfield in Acre, near the Peruvian frontier, will depend on future internal development of the country, or abundant capital. For this area, already proven by an international company, is too remote from a market. It was found that a pipeline nearly 600 miles long would have to be laid, through difficult country, to the nearest waterway connecting with the Amazon, making about 3,000 miles of river transportation necessary to reach Para. Brazilian geologists are, however, in Acre making their own investigations for the government.

The Petroleum Bureau of Mexico recently signed a contract with the Brazilian firm of Correa Castro e Cía, in Río de Janeiro, for the sale of PERMEX crude and refined petroleum, several shipments of which have been handled up to this time.

Brazil is also approaching the question of the national supply of petroleum prod-

(Continued on page 89)

ucts from other directions. The idea of producer-gas trucks has taken strong hold. The government recently ran trials of various makes of imported gasogene trucks, attracting much publicity, and arrangements have been made with some of the manufacturers to make these trucks in Brazil. A decree-law has been passed ruling that any enterprise operating ten or more vehicles must employ one using producer-gas for each ten gasoline vehicles. This ruling may eventually be applied to bus lines. Not only is there little danger of exhausting Brazil's source of charcoal supply, but industrial waste products provide suitable high-speed-gas fuel.

Most of the asphalt paving in Brazil is done with refinery residue. Cia. Itatig, the first concern to start drilling for oil under the laws of President Vargas' New Regime (established November 10, 1937), also has federal approval to work the huge deposit of bituminous sandstone at Guarehy, near Sao Paulo. The rock yields 12 percent of bituminous oil. A binder of national origin has been found to render Itatig's asphaltic preparation suitable for laying cold.

Another new Brazilian industry which has earned government approval is the shale oil development of Panal, (Cía. Nacional de Oleos Mineraes, S/A.). Running for about 43 miles, and about 12 miles wide, along the Central Railway in Sao Paulo, 87 miles from the state capital, is a bituminous shale deposit of mammoth proportions. This is only one of several in Brazil, but the only quarrying that has ever been done is that of the above deposit. At a point called Tremembé, Panal has a concession to work several square miles. Exact depth of the deposit is unknown. It begins about three feet from the surface, and samples taken down to 800 ft. show improvement of quality with depth. Even with Panal's present distilling equipment, the high average of 15 to 20 percent of oil per ton of shale is obtained, a result verified or bettered by tests of this shale made in European laboratories. In quality uniformity, and accessibility this deposit is probably the best in the world.

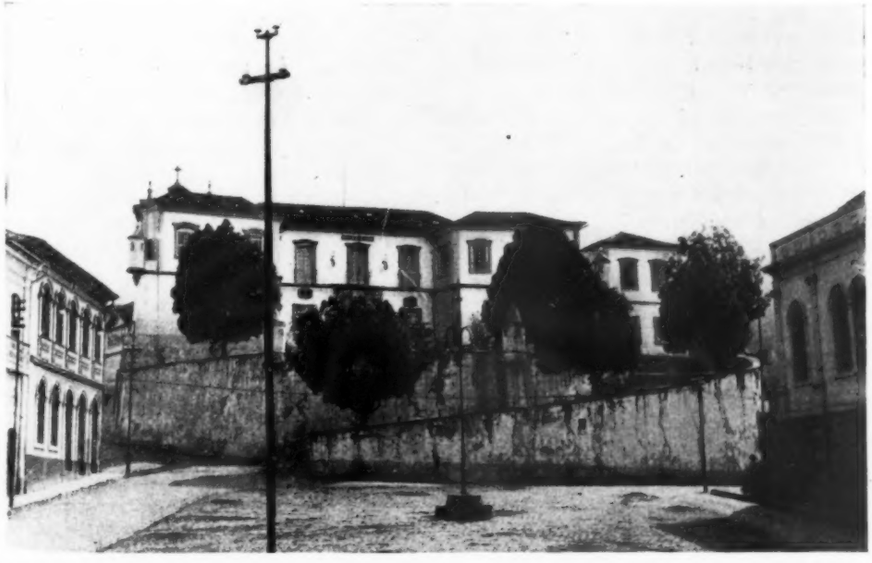
A gallery in the world's richest oil shale deposit in Tremembe, Sao Paulo. Dr. Nelson Dantas, president of Panal, is the short man in the center of the group.

At Taubaté, about 12 miles from the Panal quarry, is the old works of the English company who produced the town's supply of illuminating gas from shales, from 1887 until the substitution of electric lights in 1910. These works Panal has converted into a refinery, with capacity to work 30 tons of shale per day, producing four tons of crude oil. This is being accumulated in anticipation of projected plant to refine 3,000 tons of shale daily, in which event this refinery will be the largest of its kind the the world, slightly exceeding Australia's new 1,000,000 tons a year installation.

According to Panal's data, 3,000 tons of shale will produce 450 tons of crude oil, 10,500,000 cu. ft. of gas (which probably will be used by the company itself, for carbonizing), 21,000 cu. ft. of ammoniacal water, containing six percent sulphate of ammonia, and 1,500 tons of coke.

The 450 Tons of Crude Shale Oil Will Yield:

Percent		Gallons
25	Gasoline	29,722
15	Kerosene	17,833
10	Diesel and Gas Oil	11,889
10	Lubricating oils	11,889
15	Creosotes and Phenols	17,358
		Tons
8	Paraffin	40
3	Coke	15
2	Ichthyol	10
2	Toluol	10
10	Other products	50



Ouro Preto School of Mines where Brazil's future geologists receive their technical training in a six year mining course.

A fine quality of asphaltic residue from the cracking process, as well as valuable residues from the refined shales make this an attractive proposition under Brazil's new protective policy, in spite of the costlier refining process. Derivatives from the shales furnish certain materials expensive to import, used in refining sugar and vegetable oils, both important Brazilian industries. Other useful by-products are employed in making explosives, and fertilizers. The shale itself, minus the oil, consists of fuller's earth, which should prove advantageous to the budding national petroleum refinery industry. Panal specimens may be seen at the World's Fair, N. Y.

Because of the measures to keep wealth in the country, as well as the laws now applied to foreigners, Brazil has ceased to attract non-resident investors. Solution of Brazil's petroleum problems depends on how well she manages to jump her financial hurdles, dissociated from outside capital.

DEVELOPMENT ALONG THE S

@ Aerial Survey

International Petroleum Company's camp at Talara, Peru on the Pacific coast of South America.

SOUTH America is perhaps one of the most important oil areas in the world not only because of its present potential production, but also because of the vast amount of exploration going on there. Activities in Brazil and Eastern Peru are covered elsewhere in this issue. It is interesting to note that on May 26 the National Petroleum Council of Brazil awarded contract to Geohydro, Limitida, for drilling three test wells for the government in the government's reserve area of the Reconcavo da Bahia and in the State of Alagoas. Geohydro is headed by Dr. Romeo Marquez and is acting as agent for J. E. Brantly's Drilling and Exploration Co. The bid was prepared by Mr. Brantly who will personally superintend the operations. His success in Eastern Peru produced a very favorable reaction in Brazil.

TRINIDAD

Trinidad, most important producer of the British Empire, while not politically, is at least geologically allied to South America. During 1938 this island reached its peak production of 17,736,176 bbl. indicating production at the rate of 48,592 bbl. per day. Production for the first quarter of 1939 showed an increase over the previous year, being reported as 53,138 bbl. per day. During 1938 a very active drilling and development campaign was carried on with a total of 905,878 ft. drilled during the year.

Outside of exploratory wells the greater part of the drilling was intended to extend producing fields laterally. The previous year some deep drilling had been undertaken but results were hardly commensurate with the expenditure involved.

The most important exploratory wells now being drilled are located in Trinidad Northern Areas, some distance north of the developed producing fields. These tests are being drilled with heavy Diesel rigs capable of over 10,000 ft. Locations are based on extensive geophysical surveys, including seismograph, gravity and magnetometer methods, but it may be some time before drilling results are known.

In the southern part of the island two tests were drilled by Trinidad Petroleum Development and one by Apex (Trinidad) Oilfields between the developed Palo Seco field and the smaller Coora field. These tests established that Palo Seco and Coora are connected and the area between contains an important extension of the existing fields. Trinidad Leaseholds has been drilling several tests in the southwest portion of the island in the Mayaro district and while the results of these tests have not been announced there is reason to believe that indications of commercial deposits exist here. United British Oilfields of Trinidad drilled on the flank of the old Point Fortin field and were successful in establishing good production near the proposed sight of the company's new refinery. Two wells drilled northeast of the Coora field by Trinidad Consolidated failed to uncover commercial deposits but five wells drilled by Petroleum Options, Ltd., in the Moruga area are said to have revealed promising shows. The result of production tests on these wells has not yet been announced.

Antilles Petroleum, in which The Texas Co. is interested to some extent, drilled a deep test at Point Ligoure just south of the Guapo fault and obtained production at 7,000 ft.

VENEZUELA

Biggest producer in South America is, of course, Venezuela, third largest oil producing country in the world, being topped only by the United States and the

SOUTH AMERICAN OIL BELT

Central camp of the Y.P.F. in the great Comodoro Rivadavia field from which comes 80 per cent of Argentina's crude oil.

U.S.S.R. In 1938 Venezuela produced 173,506,497 bbl. or 475,360 bbl. per day. Since January 1 production has been stepped to 532,098 bbl. per day, which if continued will make total production for 1939 considerably in excess of 1938.

Over 4,000 wells have been drilled in Venezuela and well over 2,000 of these are producing at the present time.

It has been estimated that $300,000,000 has been invested and cumulative production to April 1, 1939, is 1,725,000,000 bbl. Principal companies operating in Venezuela are the Royal Dutch Shell Group through Venezuela Oil Concessions, Ltd., Caribbean Petroleum Co. and Colon Development Co.; Standard Oil Co. of N. J. through Lago Oil Corp., Standard Oil Co. of Venezuela, and Creole Petroleum Corp.: the Gulf Oil Corp. through Mene Grande Oil Co.: also the British Controlled Oilfields, Ltd. In addition Socony-Vacuum Oil Co., Pantapec Oil Co., Quarico Oilfields (Venezuela), Ltd., Caracas Petroleum Corp. and the Standard of California have been carrying on exploration and test drilling. The Texas Co., Consolidated Oil Corp., and Atlantic Refining Co. hold concessions.

Fields in the Lake Maracaibo area have reached the settled production stage with some drilling out in the lake. Some 70 percent of Venezuela's crude production comes from this area. Production is from a strip 45 miles long and 20 miles wide in its widest part. Production is obtained from wells on the shore, in shallow water offshore and in the last few years from wells located as far as five miles out in the lake. To date 1,200 wells have been drilled and some 700 of these are currently producing. The average depth is 2,225 ft. Drilling program in the lake region consists of 26 strings now in operation. Some of the lake wells are drilled in as much as 50 ft. of water and general practice is to sink 12 concrete piles 133 ft. long by 2 ft. square weighing 40 tons as a foundation. On this base 112 ft. derrick is erected and power is obtained from a drilling barge. Wells in the lake are completed in an average of 17 days. Gathering lines are laid on the lake bottom in 90 ft. lengths.

Southwest of the lake, near the Colombian border are the Terra and Los Manueles fields, discovered in 1916 and currently producing 13,000 bbl. per day from 40 wells. Average depth is 3,000 ft. in Terra and 4,200 ft. in Los Manueles. The crude is 33 deg. A.P.I. Three strings of drilling tools are kept in operation in these fields and a 90 mile eight-inch pipeline conveys the oil to a loading terminal in the lake. These wells are almost within sight of the Barco concession in Colombia.

Concepcion and La Paz fields lie a few miles northwest of Lake Maracaibo. La Paz was discovered in 1922, now produces 2,100 bbl. per day of 20 deg. A.P.I. oil from 23 wells. Depths range from 600 to 2,400 ft. Concepcion was discovered in 1924, produces 2,500 bbl. per day from 80 wells averaging 3,200 ft. deep. Gravity varies from 28 to 40 deg. A.P.I. A 17-mile six-inch pipeline carries the oil to Venezuela Oil Concessions lake loading terminal at Punta Piedras.

Another important group of fields in the western part of Venezuela is El Mene—Media—Hombre Pintado a short distance northeast of the lake. Commercial production began in El Mene in 1924 and the field is practically drilled up with the exception of a deep test now in progress. Depths range from 900 to 2,400 ft. and the crude is 36 deg. A.P.I. In the Media field the wells are deeper—3,800 to 4,000 ft. but the oil is the same gravity. In Hombre Pintado average depth is 4,500 ft. and the oil is 28 deg. A.P.I. In this field further development is contemplated and a two string drilling

An Oilwell rotary drilling unit in the Palo Seco field in Trinidad where production and drilling activity reached a peak last year.

campaign is kept up. There are 78 producers in El Mene, eight in Media and three in Hombre. Together they produce about 1,900 bbl. per day and are operated by British Controlled Oilfields, Ltd. The production is shipped to the mouth of the lake via eight-inch pipeline 35 miles long.

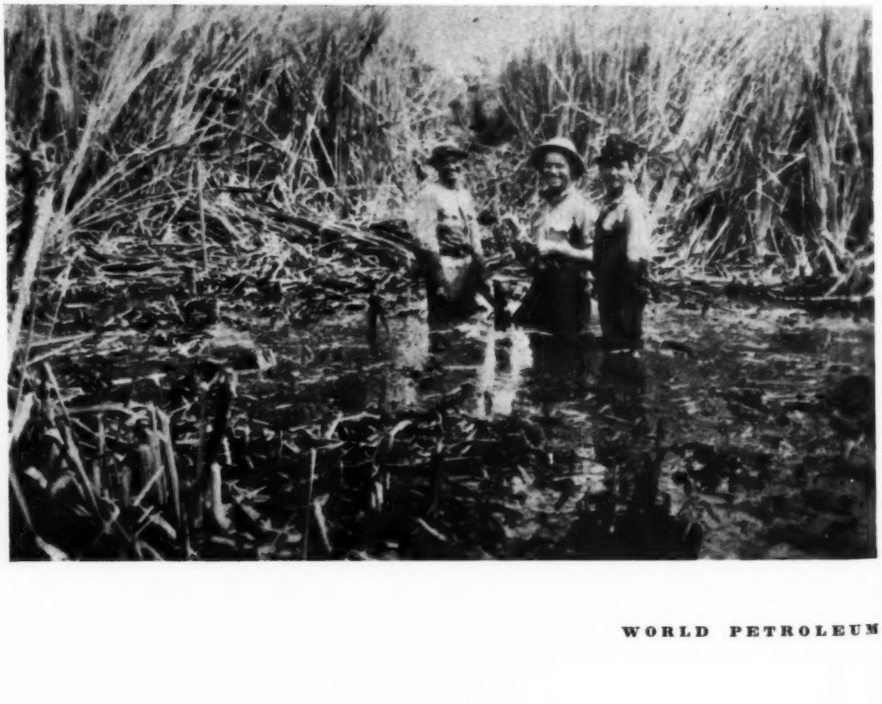
One of the most profitable fields in Venezuela is the Cumarebo, discovered in 1931. It lies within four miles of tidewater about 185 miles northwest of the lake. It produces at the rate of 20,000,000 bbl. per year of 50 deg. A.P.I. oil which flows by gravity to the port of Tucupido where a marine loading line extends 1½ miles into the ocean. Repressuring is accomplished through four wells. The wells are shallow, ranging from 500 to 1,300 ft. Approximately 108 wells have been drilled of which 52 are producing. Two strings of tools are in use and drilling time is approximately one month.

Eastern Venezuela has attracted attention for many years as an area of great potential possibilities. Recently the Oficina and Santa Ana fields have been developed and a 100 mile pipeline and road will soon be completed to permit shipment of oil from these fields. Oficina was discovered in May 1937 and has shut in production of 2,000 bbl. per day. The oil is produced from 6,000 ft. and is 28 deg. A.P.I. Eight wells are presently drilling in this field. Santa Ana was discovered more recently. The pay is found at 7,640 ft.

Other fields of interest in this section are Quiriquire, Pedernales and Temblador. The first of these produces a 17 deg. A.P.I. crude and the last two produce 16 to 23 deg. A.P.I. crude. Wells are 2,000 to 6,000 ft. deep. Twelve strings of tools operate in these three fields. In Pedernales drilling is done from barges equipped with Diesel-electric rigs and is very expensive.

A number of wildcats has been drilling in Eastern Venezuela. Jusepin No. 1 opened a new field in October 1938 when it came in from 5,000 ft. for 775 bbl. per day of 32 deg. A.P.I. crude. The field is located 25 miles southwest of Quiriquire and other wells are being drilled there. Southwest of Temblador near the Orinoco River, Venezuela Oil Development brought in Cerro Negro No. 1 for 120 bbl. per day from 3,700 ft. while Standard of Venezuela abandoned its Camorra No. 1 at 2,948 ft. only a few miles from the successful Cerro Negro. Three subsequent Cerro Negro wells are drilling.

All in the day's work for this seismograph crew exploring the Motatan del Rio area of Venezuela for California Exploration Co. (California Standard).



Socony-Vacuum is drilling a test with a medium weight Diesel rig in the State of Guarico just east of the Iguana river, a few miles north of the Orinoco. This company has geophysical crews in the field and plans further test drilling during the year. The present test is known as Iguana No. 1.

Also in Guarico, and some 75 miles northwest of Iguana No. 1, the Caracas Petroleum Corp. spudded in a test well during April of this year. They are using a medium Diesel rig capable of 5,000 ft.

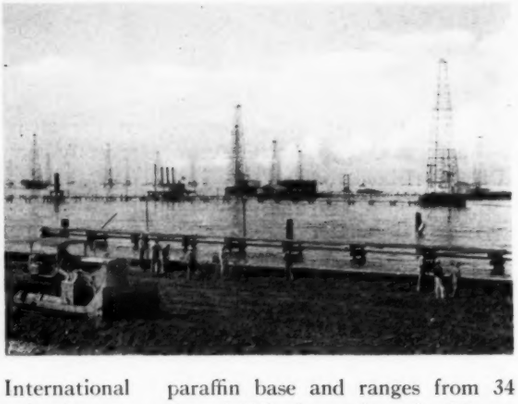
Mention should also be made of the El Roble field recently opened up between Oficina and the port of Guanta. This well was drilled by Standard of Venezuela. The deepest well in Venezuela, Mototan No. 1, was drilled by Lago last year to 9,670 ft. where it was abandoned. The Texas Company is drilling a test in Eastern Venezuela near Santa Ana. Other wildcats in this area are Standard of Venezuela's Indios No. 1 drilling at 4,000 ft. early this year, Mene Grande's San Joaquin No. 1 shut in at 4,800 ft., in January, San Joaquin No. 2 drilling at 7,900 ft. in March and Guarico Oilfields' Guayabo No. 1 drilling at 5,380 ft. in May.

COLOMBIA

To the west of Venezuela lies Colombia, scene of widespread activity. Operations in this country were thoroughly reviewed in the March 1939 issue of WORLD PETROLEUM.

There are two important fields in Colombia: the El Centro field, 335 miles up the

VENEZUELA, COLOMBIA & TRINIDAD
CARIBBEAN SEA
GUAJIRA
MAGDALENA
BOLIVAR
ANTIOQUIA
SANTANDER
NORTE DE SANTANDER
TACHIRA
BOYACA
ARAUCA
APURE
ZAMORA
PORTUGUESA
TRUJILLO
LARA
FALCON
YARACUY
CARABOBO
ARAGUA
MIRANDA
GUARICO
ANZOATEGUI
MONAGAS
SUCRE
DELTA AMACURO
BOLIVAR
Lake Maracaibo
Barranca Bermeja
El Centro
Petrolea
Rio de Oro
Los Manueles
Encontrados
Cucuta
Barranquilla
Cartagena
Santa Marta
Cumarebo
Coro
Caracas
La Guaira
Maracay
Valencia
Barquisimeto
Carora
Trujillo
Maracaibo
Merida
San Cristobal
Barinas
San Fernando
Ciudad Bolivar
Puerto La Cruz
Cumana
Carupano
Maturin
Quiriquire
Pedernales
Port of Spain
Trinidad
El Roble
Sta Ana
Oficina
Tembladora
Salto
Orinoco
Rio Meta
Rio Magdalena
Rio Zulia
Rio Catatumbo
Lake Valencia
Rio Caroni
Rio Guarico
Rio Portuguesa
Rio Apure
Rio Arauca
Rio Negro
Rio Guaviare
Rio Casanare
Rio Cesar
Rio Sinu
Rio Cauca
Rio Suarez
Rio Tachira
Rio Uribante
Rio Caura
Rio Paragua
Rio Caroni
Rio Orinoco
Rio Grande
Rio Juncal
Rio Negro
Rio Zulia
Rio Catatumbo



Standard of California through its subsidiaries is acquiring a tremendous file of subsurface information in all parts of the world. The two top pictures show the Geophysical Service, Inc. camp in Colombia carrying on exploration work for Richmond Petroleum Co. To the right, Caterpillar Diesel working on the lake wall at Lagunillas, Venezuela.

pany operating in Peru is the International Petroleum Co. which accounts for 80 percent of the total output. The two other companies are Compania Petrolera Lobitos, Ltd., and Compania Petrolera Zorritos.

International has drilled some 2,000 wells and produces about 23 bbl. per well per day. Reserves were estimated at 1,200,000,000 bbl. Production is obtained from four pay sands, the first located at 1,300 ft. the second at 2,400 ft., the third approximately 4,000 ft. and the fourth at 6,000 ft. Lobitos properties lie to the north of International's and consist of 300,000 acres where 725 wells have been drilled with an average yield of 12 bbl. per well per day. Reserves of this company have been estimated at 75,000,000 bbl. Zorritos, which is controlled by Peruvian capital, owns property still further north, has about 45 producing wells and averages three barrels per well per day.

The Peruvian Government recently drilled a test some 65 miles inland from the Negritos field of the International. The test, drilled with a Franks Manufacturing slim hole rig, reached 3,295 ft. in 19 days and was plugged and abandoned at that depth. It is reported that two other tests have been drilled in this area by the Peruvian government since then but details have not yet been made available.

Altogether there are about 2,700 wells in Peru. The crude is of mixed asphalt and paraffin base and ranges from 34 to 38 deg. A.P.I. Approximately 80 percent of Peruvian crude is of high cold test.

ARGENTINA

From Peru the oil belt swings inland and continues south through Bolivia where oil operations are temporarily suspended due to the government seizure of the properties held and operated by Standard Oil Co. of Bolivia. Reports have been current that Bolivia will operate the fields developed by Standard in the eastern end of the country and ship oil through Paraguay and Argentina to Germany on a barter arrangement. However, no important drilling activity is likely to occur in Bolivia until this confiscation is settled.

First commercial production in Argentina was developed in 1907 in the province of Chubut on Federal reserves in the field known as Comodoro Rivadavia. Since then commercial production has been found in three other areas; the province of Salta near the Bolivian border (Agua Blanca and Tartagal), the province of Mendoza in foothills of the Andes (Cacheuta) and at Neuquen, south of Mendoza (Plaza Huincul).

Comodoro Rivadavia is by far the most important, producing 82 percent of the country's output. The Yacamientos Petroliferous Fiscales (Y.P.F.), government controlled producing, refining and marketing organization, is the largest single producer. In addition, Jersey Standard, Royal Dutch Shell and Texas-Socony interests operate in Argentina. The Y.P.F. is responsible for almost 50 percent of the country's production and the trend is toward gradual concentration of more and more of the industry in the hands of the Y.P.F. About 300 wells were drilled last year of which only eighteen or twenty were wildcats. Altogether over 5,000 wells have been drilled in Argentina. The policy of the government in not granting new concessions to the international oil companies has resulted in less interest in exploration than the geological indications might otherwise warrant. During 1938, Argentina produced 17,076,223 bbl. of oil, or at the rate of 46,784 bbl. per day. Production in 1939 will probably be higher: for the first quarter production has been at the rate of 57,778 bbl. per day.

BRITISH GUIANA

In addition to the foregoing Latin American countries of established production reference should be made to the work going on in British Guiana. British Controlled Oilfields, Ltd., carried out seismograph exploration and sank a test well (WORLD PETROLEUM, page 141, April, 1930) in Territorio Delta Amacuro several years ago. Recently an exclusive license to explore for oil in the Northwest Coastal region has been granted British interests represented by the Central Mining and Investment Corp., Ltd. Oil indications are said to have been found in this region. The chief geologist of the company arrived in British Guiana early this year and in

Transporting seismograph equipment used by Atlantic Refining Co. in exploration of Cuba's potential oil resources. Two wells have been drilled by Atlantic and over 15,000,000 acres studied by geophysical and geological parties.

February a party of geologists and engineers started work around Skelton, B. G.

GUATEMALA

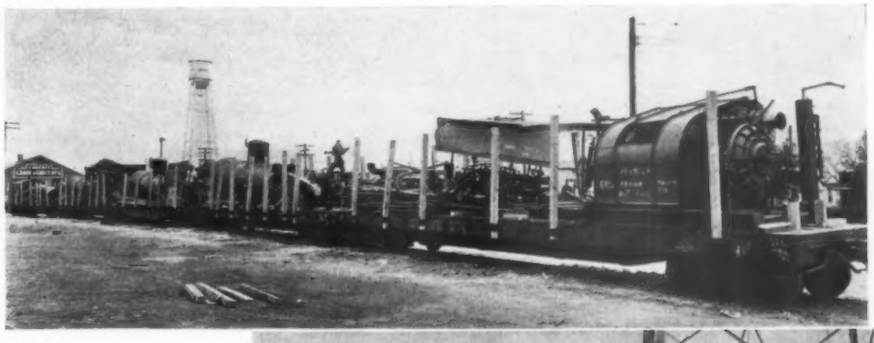
In Guatemala, Shell interests, through a local company, Cia. Guatemalteca de Petroleo Shell, are exploring concessions covering about 3,000,000 hectares, mainly in El Peten in the northern part of the country. Apart from geological and geophysical work, the chief activity has been an aerial survey of the concessioned area. The survey was commenced towards the end of 1937 and would have been finished before the middle of 1938 had it not been for extremely unfavorable weather conditions, necessitating a resumption of the work towards the end of 1938 for the purpose of completing the program. It is to be expected that further exploration work and the possibility of drilling will largely depend on the results of field geological and photogeological studies.

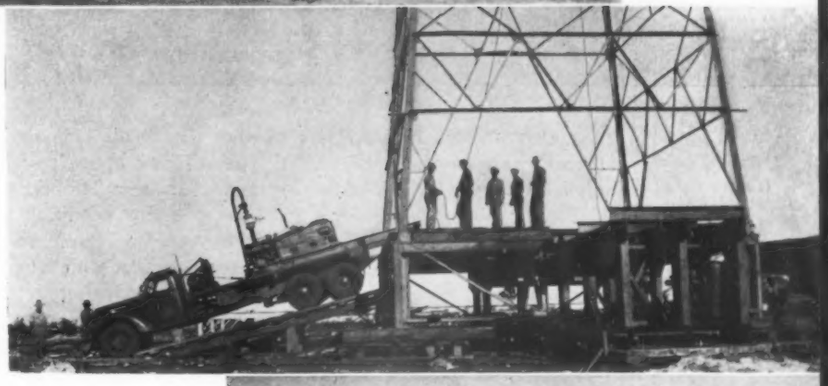
CUBA

The presence of small quantities of oil has long been known in Cuba at the natural gasoline field at Motembo, 60 miles east of Havana on the northern coast of the island, and also a gas and oilfield, at Bacuranao only about 18 miles east of Havana. The Cuban interests operating the Motembo field recently reorganized under the name Cia. Petrolera Nacional de Motembo, offered shares to the public at five pesos per share, and announced their intention of drilling additional wells to start in February of this year. Last year incomplete records indicate a production of 44,000 bbl. from this field.

Shell interests started drilling a test 15 miles south of Havana, in San Antonio de los Banos and expected to reach a depth of 8,000 ft. if necessary. Since then, it is reported that drilling on the first test was suspended at 5,230 ft. and a second test was spudded half a mile away. It is expected that three more tests will be completed within the next year.

Atlantic Refining Company, which holds extensive exploration concessions in Cuba, has temporarily suspended drilling on their well in the Carco concession near Remedios, Santa Clara province on the northern coast about 150 miles east of Havana after hole reached a depth of 4,034 ft. This location had been made on surface evidence of an anticline. Most of the drilling was through hard line formations where it was necessary to inject hay and bagasse into the hole in an effort to seal off numerous caverns that marked the formation. The heavy duty steam rig has now been moved westward in the direction of Havana to a new location two miles north of the city of Colon in Matanzas province. This test had reached a depth of 3,326 ft. by June 7, 1939, and is located on a geophysically determined structure in Atlantic's Criollo concession. Atlantic Refining is the leading company from the point of view of continuous explorations in Cuba. They now maintain two seismograph and one gravimeter party elsewhere on the island.





From Texas to Cuba: these views show equipment leaving Texas for a test location in Santa Clara province of Cuba, rigging up Puntilla No. 1 near Remedios, and drilling the well work on which was later temporarily suspended at 4,034 ft.

37% SAVING Possible With Slim Hole Drilling

Slim Hole Drilling Developed in Effort to Reduce Cost of Exploratory Drilling Finds Use for Production in Prorated Fields of U.S. and Exploration in Jungle.

AN INTERESTING development of the past two years has been the practice of slim hole drilling in the Mid-Continent and Gulf Coast regions. By slim or small hole is generally meant a drilled hole of the smallest diameter in which it will be convenient to use conventional drilling principles and tools, and into which the smaller sizes of commercial instruments may be run and used with safety and accuracy. A further qualification is that the small hole should be no wider than is necessary to admit the minimum sized casing that can be gun-perforated, and from which production or production data may be obtained by natural or by convenient artificial means.

However, the drilling of small holes is not exactly new in the petroleum industry. It is quite usual in deep oil-well drilling to start with a wide hole which is progressively narrowed as greater depths are reached and is finally completed as a hole only a few inches in diameter. Oil men and mining engineers are also familiar with small core holes which have been sunk from the surface to depths of 1600 or more feet in quest of geological information.

Small hole drilling in its more recent sense appears to have been first employed in the Mid-Continent region. Mid-Continent production is spotted and erratic in character, especially in Kansas and other regions where oil trends are of the shoestring variety. In such regions the productive life of an oil well is frequently short and ultimate recoveries are low. Operators are therefore obliged to conduct a considerable exploratory program in order to maintain even a favorable position as to reserves. There is also to consider the disagreeable fact that, owing to the erratic nature of the structures, an exploratory test will condemn or prove only a very limited area. Hence little conclusive evidence can be obtained from just one test, and as a usual thing several tests are required to ascertain the value of a large block of acreage.

Meanwhile, since it is necessary to maintain large amounts of acreage under lease, the operator is confronted by a large expense for rentals on territory that awaits exploration. Furthermore, even in proven fields there is the problem of defining margins, which calls for exploratory wells that involve a prospect of heavy expense if the outlying terrain is tested by conventional large scale equipment.

All these considerations pointed to the desirability of a system of drilling that would be free of the limitations of the geological core hole on the one hand, and on the other hand less expensive than the conventional system. This is said in full awareness of the fact that enormous improvements have been made in conventional rotary drilling; but the costs of drilling large holes have not been thereby reduced, because the mechanical savings have been absorbed by the rising costs of material and labor.

Attempts to lower the cost of drilling reduced-size holes by using somewhat smaller standard oil-field casing were first made with conventional sized rigs. In most cases one step-down in casing size was made, from about seven inches to 5½ in., but at first the reduction in hole size did not show much saving when the conventional size drilling rig was used. In fact, it was mostly the other way around, because drill

pipe and bits of the smaller sizes did not stand up as well as the larger ones, so what was saved by using smaller casing was lost by the higher cost of drilling the hole of smaller diameter.

However, the need of reducing the high cost of drilling necessary exploratory wells in the hard-Mid-Continent formations had to be met, and operators began to experiment with idle core drill machines equipped with small rock bits. Rock bit and drill pipe manufacturers took notice, and after recognizing that there was a probable market for such small sized equipment, did much development work in this direction. Their success is evidenced in the fact that small size drill pipe is now proving cheaper to operate than the large sizes, and that small, modern rock bits offer service equal to 85 percent of the larger sizes. At first the small rigs were used tentatively on shallow formations, but as bits and accessories were improved and confidence was gained, lower depths were sought and small holes are now currently sunk in this region to 4,000 ft. and beyond.

Since the only reason for resorting to small hole drilling is the possibility of saving money, economy must be applied to every operation and to every piece of equipment that enters into the question. Being used mainly for exploration purposes, mobility of the outfit is an important consideration. Moving from one location to the next should be accomplished with the least expense. In other words, the small hole drilling outfit should be readily portable.

This requirement has been met by several types now on the market; mobile outfits are available which will carry the whole drilling plant on a truck or tractor-trailer, and in some cases on a skid. An outfit capable of drilling a small hole 4,000 ft. or more deep will consist of two pumps, two Diesel engines, a drawworks and a mechanically raised and lowered portable derrick. The Diesel engines are usually of the multi-cylinder type capable of a wide speed range, and weighing 11 to 18 lbs. per horse power; their only need for water is for cooling purposes. The complete outfit, including the truck, weighs in the neighborhood of 64,000 lbs.; skid mounted models weigh less. In general, the total weight of these portable rigs ranges between 50,000 and 75,000 lbs., exclusive of the drill pipe. Conventional rigs weigh 100,000 lbs. or more.

Another model answers the following description. The rig is mounted on a four-wheel drive truck which is powered with a 125 h.p. 6-cylinder Diesel engine. When in moving order a 58-ft. mast folds over the truck; a stacking board allows 125 joints of 3½-in., 30-ft. length drill pipe to be stacked in singles. Two 4½ by 6-in. mud pumps are mounted behind the truck cab. Alongside the pumps is mounted a 125 h.p. 6-cylinder Diesel engine similar to the truck engine; either engine is available for drilling or for operating the pumps. The drawworks are mounted over the rear wheels and has five speed changes available. The rotary table is carried on the rear of the truck. Rotary table speeds may be varied from 20 to more than 100 r.p.m., and it is possible to set a 10¾-in. O.D. casing through the table; 8⅝-in. O.D. casing has been successfully set at 700 ft. The oil string is 4½-in. O.D., 9.5 lb., 10 thread seamless casing.

As a contribution to reduction of expense involved in the erection and dismantling of conventional derricks there are now being offered shop-fabricated masts and portable derricks that can be mechanically or hydraulically raised or lowered. These are mostly around 60 ft. high and are suitable for drilling to reasonable depths in hard-formation areas. There is even available a 92-ft. conventional derrick that may be raised or lowered by means of the drawworks drum.

The substitution of masts for the derrick on portable rigs has received the enthusiastic approval of some operators, particularly in some of the newly opened shallow Illinois fields. Use of the mast dispenses with much of the time required to put up the derrick.

The choice of Diesel engines for power is self-evident for portable rigs, because of the bulk and weight of steam equipment, and because of the uncertainty of finding supplies of water and fuel; the possibility of obtaining local electric current is also generally remote. Gasoline engines have also been used successfully.

Some of the first operators who embarked on small hole drilling had the idea that the smaller the diameter of the hole the less it would cost to drill it, but it was found that very narrow holes were excessively troublesome. Holes narrower than six inches are not now considered very practicable. A number of wells have been drilled in the Mid-Continent with 6¼-in. hole and cased with 4½-in. O.D., 9.5 lb. seamless casing. Two major companies have used portable rigs that drill a 6¾-in. hole with 3½ in. O.D. external upset full hole drill pipe. One company drills a 7⅞-in. hole and sets 5½-in. pipe. The average completion depths of these wells was about 3,300 ft. with a maximum depth of 4,511 ft.

As between a 6¾-in. hole and a 7¾-in. hole, one company prefers the wider one because of the advantage of a heavier drill collar than can be used in the smaller hole. The heavier drill collar provides a larger weight on the bit without overloading the drill pipe.

On the other hand, since the principal recommendation of the slim hole is its smaller cost in comparison with a conventional sized hole, and since casing is probably the one single item where the greatest savings may be made, the choice of casing size becomes important. The casing must combine the minimum diameter to give convenience in the necessary drilling operations with a minimum safety factor in collapse for the desired setting depth. It must also have a sufficient pull-out strength. Tests have shown that 4½-in. 9.50 lb. S.S. casing O.D. 4.50-in. and I.D. 4.09 in., with a 5-in. collar and 10 thread with 2 in. thread engagement has a pull-out strength of 125,000 lbs., equivalent to a length of 5,260 ft. and a safety factor of 2½. Such casing has been used on nine Mid-Continent wells ranging in depth from 2,700 to 4,100 ft., with no failures reported.

The power required for small hole drilling is not large, but must be sufficient to rotate the drill pipe and elevate it at reasonable speed, and to operate the mud pump. These pumps must have the capacity to impose the necessary velocity on the stream of mud that rises in the annular space between the drill pipe and the wall of the hole and brings the cuttings to the surface. The velocity required is about 125 ft. per minute. In the case of a 6¼-in. hole with 3-in. full hole drill pipe this velocity may be created with one 5 by 8 in. pump running at 64 r.p.m. or two 5 by 8 in. pumps running in parallel

Slim hole drilling by Shell at Okemah, Oklahoma; drilled to between 3,400 and 3,600 ft. with 8⅛ in. surface casing and 4½ in. oil string.

Typical slim hole drilling outfit in use in Western Kansas.

at 32 r.p.m., or two 4 by 8 in. pumps running in parallel at 49 r.p.m. In most cases a 100 h.p. net delivery is more than sufficient to handle these pumps up to 650 lbs. working pressure.

In the Mid-Continent it is now considered that the drilling of small holes to 3,000 or 4,000 ft. has about passed the experimental stage. Some time had to be consumed in training personnel for this kind of work and to discover weaknesses in the design and practical use of this new type of equipment. Perhaps something still remains to be done in both these directions, but anyhow the matter has now been put on a going basis.

For example, one truck-mounted machine equipped with a portable 56-ft. mechanically raised derrick has been in operation in Kansas for about nine months, during which time it has drilled seven exploratory or step-out wells, having an average depth of 3,249 ft.; the deepest was 4,156 ft. The total footage drilled was 22,729 ft., of which 16,585 ft. was cased with 4½ O.D., 9.5-lb casing. Among the seven wells thus drilled one was a 2,400 bbl. producer, one was a 125-bbl. well, one a gas well, and the remainder were dry holes.

The fact that a small diameter well may turn out to produce as much as 2,400 bbl. a day shows that the small hole may have a wider use than for mere exploratory purposes and that for tapping known oil sands it will accomplish much on a relatively small drilling investment.

Nevertheless, the principal function of the small hole is considered to be the testing of unknown terrains at the least expense; at the same time it will be well to keep the possibility of production in mind, and aside from other reasons this is additional ground for not drilling too narrow a hole. It should be possible to set casing, and to obtain tests of promising formations by other ways than core analysis, such as shooting or acidizing. Unless such tests can be made it will not be possible to determine the potentiality of a horizon which may contain oil in commercial amounts; the risk is run of obtaining no return on the drilling investment and the real object of conducting the exploration, which may be to prove or condemn a given block of acreage, will not be conclusively reached.

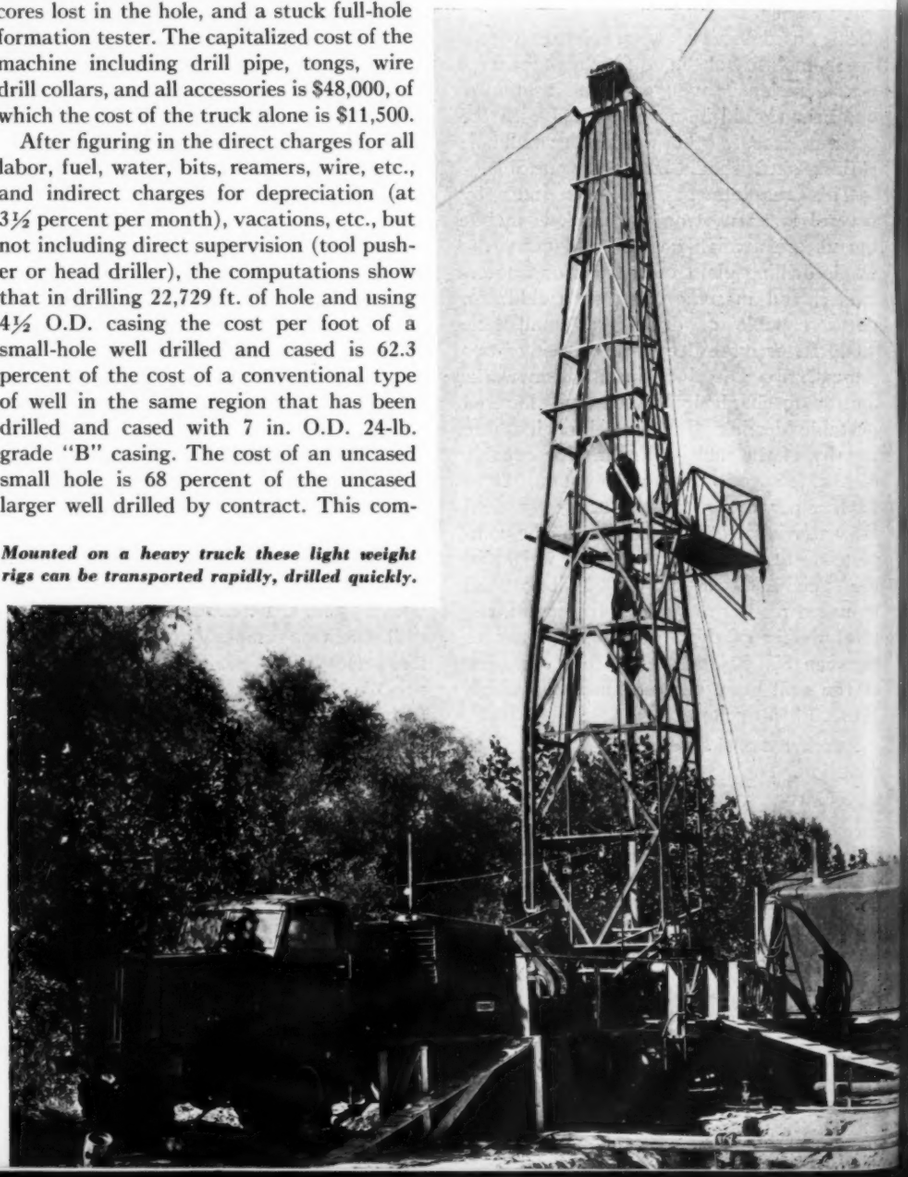
The economics of the small-hole outfit are indicated by the record of the seven-well campaign of the machine above referred to. This campaign was featured by a not unusual variety of unfortunate experiences, such as a twist-off that necessitated drilling-by, a fishing job due to cores lost in the hole, and a stuck full-hole formation tester. The capitalized cost of the machine including drill pipe, tongs, wire drill collars, and all accessories is $48,000, of which the cost of the truck alone is $11,500.

After figuring in the direct charges for all labor, fuel, water, bits, reamers, wire, etc., and indirect charges for depreciation (at 3½ percent per month), vacations, etc., but not including direct supervision (tool pusher or head driller), the computations show that in drilling 22,729 ft. of hole and using 4½ O.D. casing the cost per foot of a small-hole well drilled and cased is 62.3 percent of the cost of a conventional type of well in the same region that has been drilled and cased with 7 in. O.D. 24-lb. grade "B" casing. The cost of an uncased small hole is 68 percent of the uncased larger well drilled by contract. This comparison is based on actual bid contract price in the areas where the wells were drilled. The figures for the small hole include coring, which is usually supplemental to contracts let on a drilled footage basis. The average rigging-up time is about 60 percent less than that required for an ordinary medium sized rotary, but the average drilling time is about 20 percent greater.

In connection with the cost of slim hole drilling it is interesting to note figures included in a paper delivered by Carl White, Jr., vice president, Franks Manufacturing Corporation, before the Northeast Oklahoma Chapter of the American Petroleum Institute on February 8, 1939:

"The average cost to the company in Kansas for drilling wells in proven territories has been from $25,000.00 to $30,000.00 and for wildcat tests to 3,500 ft. has been from $30,000.00 to $35,000.00 where there has been enough show to run the oil string. . .

"Assuming a well is to be drilled on each ten acres in a pool, and taking the average for the pool, we have a total expected recovery per well of 50,000 to 80,000 bbl. or at the present price of oil, approximately $50,000 to $80,000 total return per well, or less, on a present value basis of future



Mounted on a heavy truck these light weight rigs can be transported rapidly, drilled quickly.

returns. It is obvious that if the drilling cost plus surface equipment is $35,000 to $40,000 and the lifting cost is 25c per barrel and on top of this, one-eighth royalty has to be paid, all of which totals up to from $48,750 to $70,000 to which must be added the geological, geophysical, and leasing costs, such development is no bonanza proposition. . .

"I believe the best way to point out the costs that can be obtained with slim hole portable rotary drilling rigs is best shown representing an average of many wells, not just one or two but several, in which the normal hazards were encountered. Please understand that this cost breakdown represents no particular records as certain slim hole wells have been drilled at costs considerably below this."

Average Cost of Kansas Well Drilled to Silicious Lime

(Approximately 3,300 ft.)

Cost of pit		$ 80.00
600 ft. of 8⅝ in., 28 lb., surface pipe		884.28
200 sacks of cement		170.00
Halliburton cost for cementing		85.00
3,300 ft. of 4½ in., O.D. 9.5 lb., casing		1,749.00
Hauling surface and oil string		50.00
Cementing Oil String:		
125 sacks of cement		106.20
Halliburton cost for cementing		225.00
Hauling cement (for surface and oil string)		27.50
Surface equipment including tubing rods, pumping unit, separator and tanks and cost of drilling in with spudder		6,891.90
Fixed charges of drilling, carried for'd		$10,268.88
Fixed charges of drilling, brought for'd		$10,268.88
Moving, blocking, decking, and trucking	$ 150.00	
25 days labor and insurance @ $76.00	1,900.00	
Mud, cotton seed hulls, etc.	150.00	
Tool pusher (most of time head driller does this)	300.00	
Repairs and supplies	400.00	
Diesel fuel	232.00	
Oils and greases	60.00	
Bits and cutter heads	1,032.00	
Water	300.00	
Depreciation, rig less drill pipe, $40,000 at 3½ per cent per month (25 days)	1,166.65	
Depreciation, drill pipe, 1½c per foot per day (3,300 ft. in 25 days)	618.25	
Flexible charges of drilling		$ 6,308.90
Complete cost of drilling 3,300 ft. well based on 25 days operation		$16,577.78

Comparison of Slim Hole to Big Hole Drilling

(Using above Slim Hole Cost Figures)

			Saving With Slim Hole Unit
Pits:			
Big hole	$ 100.00		
Slim Hole	80.00		$20.00
Drilling:			
Big hole (hole and core)	11,175.00		
Slim hole (hole and core)	6,308.90		4,866.10
Surface pipe:			
Big hole, 10¾ in., 32.75 lb.	960.72		
Slim Hole, 8⅝ in., 28 lb.	884.28		76.44
Oil String:			
Big hole, 7 in., 24 lb.	3,844.17		
Slim hole, 4½ in., 9.5 lb.	1,749.00		2,095.17
Cementing, hauling pipe and cement:			
Big hole	785.00		
Slim hole	663.70		121.30
Derrick—erect, tear down and move: Big hole only	650.00		650.00
Pumping unit, tankage, tubing rods, separator and drilling in with spudder:			
Big hole	8,800.00		
Slim hole	6,891.90		1,908.10
Total saving with slim hole unit			$9,737.11

However, in exploratory drilling, information at the lowest possible cost is the primary object. Light weight cheap casing with little consideration for long life or durability is used. Any commercial value that a small exploratory well may prove to have is a secondary consideration.

For production-type small-hole wells where depth, long life or anticipated heavy shooting, etc., come into consideration, the use of a heavier casing may be desirable. This class of casing may be used without any increase in actual drilling cost. It has been found that there was no increase of cost in drilling a 6¾-in. hole instead of a 6¼-in. hole; in fact, the slightly larger hole is considered safer practice. Into a 6¾-in. hole may be run at least one size of standard-weight threaded and coupled casing that will permit the satisfactory use of 2½-in. upset tubing. Based on the drilling figures mentioned above it is possible to drill and case a production-type of small well in this manner at a cost of about 14 percent less than the contract cost of drilling only.

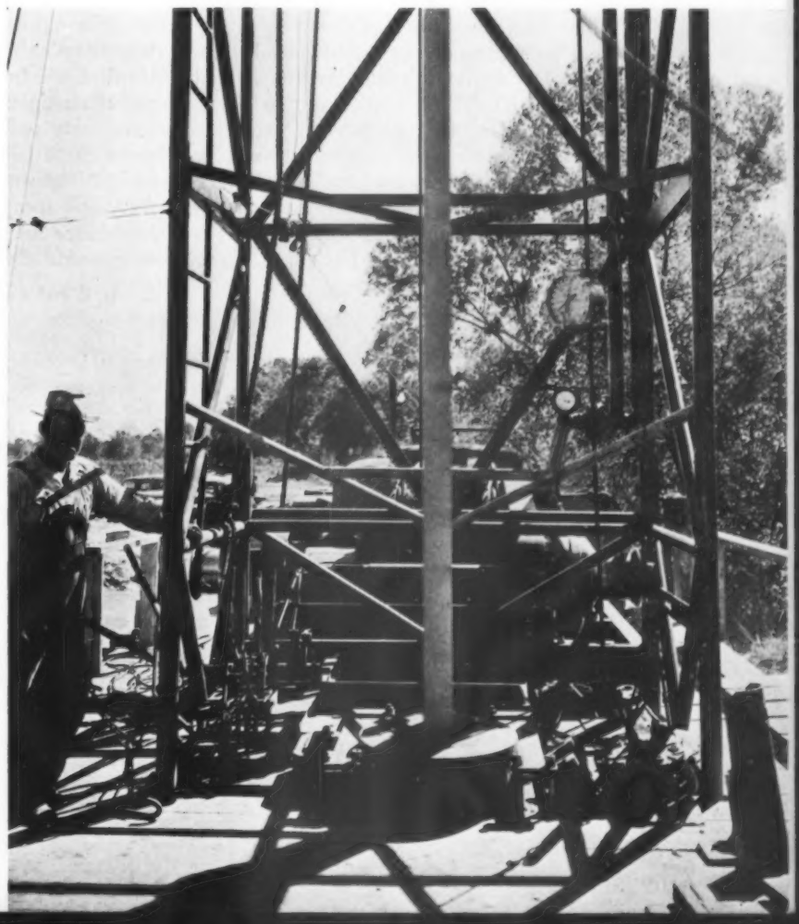
Considerable use of small-hole drilling is being made along the Gulf Coast. Here the formations are generally softer and lie at greater depths than in the Mid-Continent. Under these circumstances the small exploratory holes have been drilled 8,000 to 9,000 ft. As in other places, the cue for small-hole drilling was taken from the old practice of geological core drilling, but the first attempt to drill such a hole to a depth of 9,000 ft. encountered obstacles and the hole was completed only after much difficulty. One company first began with a 6¾-in. hole, but now makes a 7¾-in. hole, and finds that the difference of one inch considerably simplifies matters; for one thing, it permits the use of a longer and heavier drill collar, which provides the necessary weight for fast drilling.

Gulf Coast experience has been that where the equipment is adequate and well designed, the number of cubic feet of formation brought to the surface in a small hole per unit of time is the same as that brought up from a large well. The amount of formation removed being thus about the same, the speed with which hole is made is inversely proportional to the squares of the diameters; this shows one of the reasons why the small hole is a time saver. It has been possible to sink a small hole more than 7000 ft. in less than half the time required by a larger hole according to standard practice.

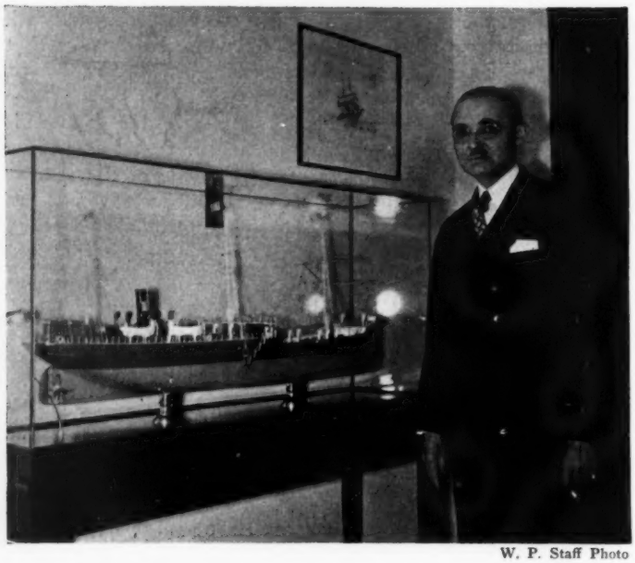
In the Coast region the average cost of drilling small holes in the depth range of 5,000 to 8,000 ft. is about $2.00 a foot. What this means may be inferred from the fact that to define a Gulf Coast salt dome it has sometimes required three or more exploratory holes at a total cost of nearly $500,000. A small-hole outfit now accomplishes the same exploratory work for less than $100,000. Practically all items such as bit costs, mud costs, drill pipe, pump and power costs are proportionally less for the average small-hole well. There is also the difference in time consumed in moving from one location to the next.

Many Gulf Coast small-holes are drilled as open holes below the surface casing. It is said that the small hole responds better than the larger holes to electrical logging.

As in other places, the practice of small-hole drilling is spreading in the Gulf Coast beyond its original field of exploration. It has been employed to produce distillate leases, where it has distinguished itself by its low cost, and it has also been employed to exploit wet gas zones which are known to be short-lived.



Close up of the miniature table in action: while useful for exploration purposes, the slim hole also finds economic justification in Oklahoma and Western Kansas where maximum allowable under proration can be produced through the small diameter hole at greatly reduced drilling cost.



W. P. Staff Photo

Robert F. Hand standing beside a model of the Gluckauf, first tanker constructed on the principles which have lasted to this day for efficient bulk oil transport. The Gluckauf was built in 1886.

Norval Baker, chief geologist, Iraq Petroleum Co.

W. P. Staff Photo

Foreign Oil Legion

ROBERT F. HAND, formerly assistant general manager of the marine department for Jersey Standard, has been appointed to succeed his former chief, the late ROBERT HAGUE who died on March 8th. He has also been made a vice-president and director of Standard Oil Company of New Jersey. Mr. Hand originally joined the company as an office boy, rising steadily through various departments until now he has charge of what is probably the largest privately owned fleet of merchant ships in the world. He has not only been a member and supporter of the International Lifeboat Racing Association, with its annual races in New York harbor, but in recent years he has taken an active part in the development of the merchant marine through the American Merchant Marine Institute, and has been interested in aiding the country's safety-at-sea programs. In his spare time Mr. Hand has gained some renown in the town of North Plainfield, N. J., for the beauty of the flowers he grows on his grounds.

CHARLES A. RODSTROM, chief clerk of the production department for The Bahrein Petroleum Company Ltd., sailed from New York for London May 31st on board the MANHATTAN en route to Bahrein Is. after two years in the United States. He w ll take up residence and make his headquarters in the city of Manama, where he will be Bahrein representative of California Arabian Standard Oil Company Ltd., although his time will be divided between the island and the mainland of Arabia. Mr. Rodstrom is not new to Bahrein, for he spent three years there before coming to New York, and his son was the first child born in the Awali oil camp. Because of his intimate knowledge of conditions all travel arrangements of Bahrein personnel had been put in his hands last year. Previous to his service in the Middle East he had worked for Standard Oil Company of California in Venezuela and Colombia and had travelled all round the world as secretary to the late K. R. KINGSBURY. Mrs. Rodstrom and child are remaining in Larchmont, N. Y., until the end of the year.

NORVAL BAKER, chief geologist for Iraq Petroleum Company, Ltd., arrived in New York on board the QUEEN MARY in the latter part of May. In the United States for about two months on a combined business trip and vacation, Mr. Baker is taking advantage of the opportunity of renewing his acquaintance with the many friends he made among American oil men when he worked in Trinidad.

A. P. FAICKNEY has been elected a director of Trinidad Consolidated Oilfields, Ltd., succeeding the late SIR ERNEST MILLER, who died on March 22nd. Sir Ernest was a director of British Burmah Petroleum Company and Mr. Faickney has now been appointed a member of the board of that company.

ROBERT GAVIN, M.A. and LL.B. of Aberdeen University, left London for Trinidad on May 13th where he will assume the post of chief industrial relations officer for the Oilfield Employers Association of Trinidad.

W. P. Staff Photo

C. A. Rodstrom seated at his desk in the Chrysler Building, in New York.

Jack G. Hosmer, personnel department of California Arabian Standard Oil Company, who sailed with Mr. Rodstrom en route for the company's Dammam oilfield in Eastern Saudi Arabia, seeking relief from New York's 92 deg. temperature just before the Manhattan pulled out from her pier.

W. P. Staff Photo

CARL HAARMANN, of Pennzoil Company, sailed from San Pedro, California, early in May on board the Danish motorship PETER MAERSK en route to Shanghai. In that city he will meet his brother William who has been Pennzoil's manager in the Orient for several years, to make a survey tour of Asia before continuing to his new headquarters at Sydney where he is to add Australasia to the distributing organization maintained throughout the Orient by Pennzoil.

T. ORCHARD LISLE is returning to his post in London, in charge of the head European office of the Russell Palmer publications following a visit of over a year in the United States. He has been visiting the California, Texas, Oklahoma oilfields, and other states studying the latest developments in the petroleum industry. Leaving Los Angeles about June 10th he is driving to New York via San Antonio, Houston, Dallas, and Tulsa, and will sail on the NIEUW AMSTERDAM on July 3rd.

Mr. Lisle, who has been executive editor of WORLD PETROLEUM since its initial publication in 1930, extends a cordial invitation to equipment manufacturers' representatives and oil company officials to visit the London office of WORLD PETROLEUM at 3, Savoy Place, Victoria Embankment, WC2. His services and that of his staff will be at their disposal. Having acted as overseas representative of the Russell Palmer publications since 1932, Mr. Lisle is in close touch with the international oil business.

T. Orchard Lisle

Photos by Merchants Photo Service

At the banquet for overseas oil men at the Houston Oil Show, from left to right—Top: Homer McDuff, Standard Oil Co. of Venezuela, who has returned to Caripito; Bill Gray, also with Venezuela Standard now vacationing in Shreveport, La., and R. A. Bruce, of Assam Oil Co., Ltd., who left Houston to tour the Mid-Continent fields and is now in California studying current technique before returning to Assam, British India, via New York. Second: K. T. Daniel and B. R. Cunningham, both of Caribbean Petroleum Co.; Mr. Daniel is still in Houston while Mr. Cunningham is in the California fields with A. N. Walp, who is also with Shell at Maracaibo. Third: Bill Bettis, of M. O. Johnston Oilfields Service, with H. B. Williams, who is in the drilling department of California Arabian Standard Oil Co. at Casoc, Saudi Arabia. Bottom: H. A. Wallis, petroleum engineer for Lago Petroleum Corp. at Maracaibo, who returns to Venezuela soon.

WALLACE W. LIND, JR., of the Lago Petroleum Corporation was married to Miss Katharine Brigham Roth of Hamilton, N. Y. and Brewster, Mass., in Oranjestadt, Aruba, on May 9th. The civil ceremony was performed by the Lieutenant Governor of Aruba at the home of Mr. and Mrs. MacGregor Brown and was followed by a religious ceremony at which the Episcopal Rector of Aruba officiated. Mr. Lind is the son of Captain Lind, U.S.N., and Mrs. Lind of Washington, D.C.

PAUL RYAN of New York, a recognized national authority on the marketing of petroleum products, recently was elected president of the National Refining Company at a meeting of directors. He succeeds Edgar G. Hill, resigned. Mr. Ryan who is 39, has devoted 20 years to various phases of the oil industry and for the past ten years has been connected with marketing. He was formerly an executive of the Shell Petroleum Corporation and more recently acted in a consulting capacity for Sinclair Refining Company and the Pure Oil Company. In the April 1939 issue of WORLD PETROLEUM, Mr. Ryan collaborated with Edwin L. Kennedy in an article that discusses "Will Companies Eliminate Market Losses Before Government Does?"—conclusions reached in this article attracted widespread attention. Mr Ryan is married and has three children. At present he is in St. Alexis' Hospital with an eye injury caused by a blow from a golf ball. He will make his headquarters at the company's office in the Hanna Building, Cleveland, Ohio.

WORLD OIL P

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified

U. S. BARRELS

	May 1938	June 1938	July 1938	August 1938	Sept. 1938	Oct. 1938	Nov. 1938	Dec. 1938	Jan. 1939	Feb. 1939	Mar. 1939	Preliminary Figures Apr. 1939
United States	98,674,000	94,277,000	102,898,000	106,165,000	98,661,000	101,830,000	98,567,000	102,287,000	102,490,000	93,475,000	106,768,000	**104,460,000**
Soviet Union[4]	17,580,000	18,540,000	18,200,000	17,600,000	17,500,000	17,400,000	17,250,000	17,050,000	17,000,000	17,500,000	18,000,000	**18,100,000**
Venezuela	15,994,400	16,309,150	14,912,555	16,616,673	16,271,096	17,352,171	16,356,204	16,744,163	16,489,347	14,899,459	15,646,415	**15,200,000**
Iran[5]	6,975,256	5,792,228	5,338,990	5,861,366	5,676,998	7,136,578	7,221,080	6,624,726	6,408,776	4,982,000	7,000,000[1]	**6,900,000**
Netherland India: Sumatra	2,971,443	2,893,856	2,814,237	2,901,321	2,917,167	3,049,196	3,015,432	3,177,589	3,129,007	2,969,950	3,393,286	**3,400,503**
Borneo	1,066,281	1,013,163	1,061,980	970,690	1,069,872	1,123,102	1,090,009	1,114,535	1,115,570	1,000,937	1,134,647	**1,123,474**
Java[9]	674,927	616,845	585,086	524,384	482,417	523,623	515,160	529,658	535,297	503,441	550,097	**509,355**
Ceram	51,524	49,870	54,035	54,825	50,355	50,444	45,750	45,773	49,200	55,219	67,442	**82,914**
Roumania	4,169,000	4,015,000	4,115,000	4,075,736	3,915,029	4,028,750	3,847,324	3,969,300	3,934,338	3,638,020	3,973,053	**3,800,000**
Mexico[18]	2,484,814	2,564,886	2,864,277	3,247,904	3,416,583	3,313,182	3,098,725	3,245,558	2,470,000[1]	1,960,000[1]	2,700,000[1]	**2,250,000**
Iraq	2,332,746	2,653,579	2,806,903	2,829,528	2,621,547	2,431,949	2,420,143	2,290,777	2,414,878	1,955,122	2,699,272	**2,620,000**
Colombia	1,819,689	1,826,136	1,826,848	1,870,013	1,797,158	1,891,825	1,863,838	1,908,879	1,710,565	1,633,621	1,818,765	**1,799,000**
Trinidad	1,481,285	1,431,476	1,500,171	1,505,959	1,514,893	1,594,480	1,503,489	1,664,322	1,652,412	1,499,197	1,630,789	**1,569,298**
Argentina[1]	1,382,000	1,346,000	1,349,000	1,360,000	1,358,000	1,360,000	1,358,000	2,028,000	2,000,000	1,300,000	1,800,000[1]	**1,740,000**
Peru[3]	1,343,259	1,303,536	1,335,623	1,328,143	1,280,691	1,331,111	1,303,990	1,321,883	1,251,162	1,103,878	1,210,288	**1,200,000**
Bahrein[6]	620,746	661,602	699,176	713,149	714,349	708,962	613,281	623,907	647,988	610,766	658,822	**629,336**
Burma[7]	667,346	679,368	654,108	637,880	623,630	604,885	591,029	651,495	650,000[1]	500,000[1]	640,000[1]	**635,000**
Canada[2]	566,086	537,654	693,332	817,706	886,111	685,088	445,514	489,303	531,564	356,218	550,000	**530,000**
Brunei[8]	445,505	425,184	453,393	448,219	478,080	477,459	484,207	510,500	506,467	453,571	492,374	**466,328**
Great Germany: Old Reich[14]	329,688	326,842	346,435	342,484	328,098	331,792	307,433	313,206	448,510	330,584	395,181	**360,000**
Ostmark[18]	32,845	30,000[1]	31,062	29,453	26,772	43,697	29,000[1]	34,259	33,609	46,666	43,293	**40,000**
Slovakia	10,960	10,159	9,333	11,015	10,933	13,747	10,502	9,879	10,546	9,000[1]	10,000[1]	**9,500**
Poland	324,803	315,381	314,000[1]	328,115	321,134	330,412	318,000[1]	316,702	325,293	290,000[1]	326,000[1]	**318,000**
Japan[10]	216,078	216,707	216,707	217,525	170,597	220,451	224,255	173,737	224,885	218,594	222,368	**216,000**
British India[11]	198,872	192,656	241,191	225,897	217,058	210,348	197,809	217,528	195,000[1]	132,000[1]	230,000[1]	**215,000**
Ecuador	190,542	188,712	192,360	193,634	189,037	192,702	185,669	192,882	195,556	171,634	181,938	**175,896**
Saudi Arabia	3,794	3,477	3,550	3,459	40,556	136,947	152,632	139,038	155,605	170,865	215,270	**234,742**
Sarawak[12]	137,824	132,240	132,007	107,102	123,476	223,165	115,952	118,512	116,030	105,714	115,980	**110,982**
Egypt[13]	89,935	84,998	83,412	143,978	157,533	208,377	211,841	221,156	308,946	301,102	330,445	**328,376**
Italian Empire: Albania[16]	42,400	72,300	46,049	4,998	68,655	Nil	Nil	6,220	99,206	67,914	125,440	**83,000**
Italy	9,563	8,646	9,378	9,057	8,267	8,622	8,533	7,937	7,511	8,090	8,324	**8,100**
France	48,545	43,189	43,574	43,000[1]	41,104	42,296	40,797	48,000[1]	42,000[1]	40,000[1]	42,000[1]	**41,000**
Hungary	18,691	26,018	25,888	30,900[1]	38,240	49,800[1]	43,303	47,671	43,000[1]	36,000[1]	48,000[1]	**45,000**
Bolivia[1]	9,000	8,790	9,500	9,200	8,500	8,800	8,500	9,000	8,800	7,000	8,700	**8,500**
Other Countries[17]	6,000	5,800	6,000	6,000	50,000	48,000	50,000	48,000	50,000	35,000	50,000	**48,000**
WORLD TOTAL	162,969,847	158,595,448	165,873,160	171,234,333	163,034,936	168,952,001	163,494,401	168,191,035	167,251,068	152,364,562	172,886,189	**169,257,304**

[1] Estimated.
[2] Includes natural gasoline production
[3] International Petroleum Company and Lobitos Oilfields, Ltd. figures combined.
[4] Russian Sakhalin included with U.S.S.R.
[5] Anglo-Iranian Oil Company, Ltd., figures revised—fuel oil returned to the ground has been deducted.
[6] Bahrein Petroleum Company, Ltd., figures.
[7] Does not include Assam or Punjab, which are listed together under British India.
[8] British Malayan Petroleum Company, Ltd., figures.
[9] Includes Madura.

Official Crude Oil Production Figures for 1932 to 1938 (Revised) in Barrels

	Daily Av. Jan.-Apr. 1939	Daily Av. Jan.-Apr. 1938	Jan.-Apr. 1939	Jan.-Apr. 1938	Daily Av. 1938	Total 1938	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**3,393,258**	3,416,042	**407,193,000**	409,925,000	3,323,984	1,213,254,000	1,279,160,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Soviet Union	**588,333**	542,267	**70,600,000**	65,072,000	564,909	206,192,000	201,856,661‡	199,635,921	184,008,033	175,635,783	155,596,429	155,927,997
Venezuela	**518,627**	482,247	**62,235,221**	57,869,640	475,360	173,506,497	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940	115,615,782
Iran	**210,758**	230,805	**25,290,776**	27,696,629	214,577	78,320,840	78,109,001	62,977,950	57,520,488	57,902,092	54,440,075	49,516,697
Netherland India: Sumatra	**107,439**	91,539	**12,892,746**	10,984,739	94,625	34,538,128	33,451,511	30,469,428	28,004,595	26,336,011	22,345,172	18,570,928
Borneo	**36,455**	35,856	**4,374,628**	4,302,745	35,102	12,812,383	12,960,072	13,068,910	13,529,185	14,335,543	15,003,175	15,228,615
Java	**17,485**	20,925	**2,098,190**	2,511,015	19,056	6,955,283	7,152,931	3,618,293	3,462,440	3,778,920	3,600,816	3,837,142
Ceram	**2,126**	1,714	**254,775**	205,650	1,665	607,622	537,436	375,823	311,872	273,698	285,335	309,957
Roumania	**127,879**	134,356	**15,345,411**	16,122,692	132,508	48,366,000	52,395,725	63,532,846	61,270,072	61,849,306	53,919,708	53,651,978
Mexico	**78,167**	11,892	**9,380,000**	14,269,895	105,495	38,505,824	46,455,687‡	41,027,915	40,240,563	38,171,946	34,000,830	32,805,496
Iraq	**80,744**	83,889	**9,689,272**	10,366,682	88,778	32,404,000	30,603,660‡	29,913,150	27,410,983	7,639,849	1,094,915	871,840
Colombia	**58,016**	56,477	**6,961,951**	6,777,202	59,127	21,581,588	20,297,543‡	18,756,110	17,597,655	17,337,900	13,156,126	16,415,214
Trinidad	**52,931**	46,084	**6,351,696**	5,530,081	48,592	17,736,176	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353	10,126,121
Argentina	**57,000**	44,967	**6,840,000**	5,396,000	46,784	17,076,223	16,354,717	15,457,960	14,297,025	14,021,901	13,690,556	13,138,747
Peru	**39,711**	36,334	**4,765,328**	4,360,043	43,584	15,908,279	17,459,112	17,593,069	17,056,555	16,314,381	13,257,318	9,899,265
Bahrein	**21,224**	25,365	**2,546,912**	3,043,746	22,734	8,297,998	7,762,264	4,644,635	1,264,807	285,072	31,377	902
Burma	**20,208**	19,853	**2,425,000**	2,382,375	20,549	7,499,498	7,847,553	7,587,718	7,181,113	7,278,859	7,114,311	7,073,437
Canada	**16,398**	15,131	**1,967,782**	1,815,683	19,004	6,936,479	2,995,025	1,507,931	1,447,204	1,410,895	1,145,333	1,044,412
Brunei	**15,990**	13,872	**1,918,740**	1,664,667	14,759	5,387,214	4,397,038	3,296,938	3,302,905	2,705,350	2,035,656	1,200,026
Great Germany: Old Reich	**12,786**	10,201	**1,534,275**	1,224,066	10,548	3,850,044	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602	1,594,807
Ostmark	**1,363**	941	**163,568**	112,950	1,014	370,038	221,266	50,092	44,347	27,965	5,765	804
Slovakia	**325**	370	**39,046**	44,396	359	130,867	122,790	126,603	136,580	177,797	121,695	126,603
Poland	**10,494**	10,458	**1,259,293**	1,255,005	10,489	3,828,438	3,799,862	3,869,575	3,901,881	4,011,336	4,174,079	4,219,634
Japan	**7,365**	5,459	**881,847**	655,127	6,880	2,511,184	2,487,841	2,403,072	2,294,878	1,872,837	1,504,412	1,683,439
British India	**6,433**	6,026	**772,000**	723,196	6,384	2,330,209	2,161,653	1,978,329	2,037,810	1,921,863	1,628,803	1,743,878
Ecuador	**6,042**	6,098	**725,024**	731,740	6,184	2,257,278	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902	1,597,641
Saudi Arabia	**6,471**	97	**776,482**	11,682	1,356	495,135	64,968	19,777	Nil	Nil	Nil	Nil
Sarawak	**3,739**	4,455	**448,706**	534,604	4,452	1,624,882	1,655,565	1,547,882	1,776,593	1,942,591	2,206,815	2,329,733
Egypt	**10,574**	3,000	**1,268,869**	360,001	4,277	1,561,231	1,163,267	1,262,666	1,255,151	1,527,252	1,653,535	1,071,976
Italian Empire: Albania	**3,130**	1,375	**375,560**	165,000	1,199	437,597	380,292	219,693	41,218	17,500	11,437	9,212
Italy	**267**	301	**32,025**	36,088	291	106,083	112,700	129,653	128,615	162,449	213,534	242,563
France	**1,373**	1,407	**165,000**	168,828	1,414	516,240	507,067	534,063	529,664	700,000	786,366	755,146
Hungary	**1,433**	449	**172,000**	53,956	906	330,829	13,910	100	Nil	Nil	Nil	Nil
Bolivia	**275**	294	**33,000**	35,330	292	106,620	123,123	104,746	163,295	157,875	111,973	41,907
Other Countries	**1,525**	193	**183,000**	23,200	665	243,000	70,000	37,100	32,300	64,000	54,100	73,300
WORLD TOTAL	**5,516,344**	5,360,739	**661,961,123**	656,431 653	5,387,905	1,966,585,707	2,041,168,442	1,797,891,143	1,652,023,331	1,516,760,036	1,438,797,443	1,305,574,242

‡Preliminary

PRODUCTION

Figures in U. S. barrels of 42 gal.—Conversion ratios used are weighed averages for individual countries

METRIC TONS

	May 1938	June 1938	July 1938	Aug. 1938	Sept. 1938	Oct. 1938	Nov. 1938	Dec. 1938	Jan. 1939	Feb. 1939	Mar. 1939	Preliminary Figures Apr. 1939
United States	13,357,804	12,762,583	13,939,606	14,507,243	13,189,481	13,785,028	13,343,306	13,846,893	13,874,374	12,653,943	14,445,677	**14,135,000**
Soviet Union[4]	2,411,000	2,543,000	2,497,000	2,414,000	2,401,000	2,387,000	2,366,000	2,339,000	2,332,000	2,400,000	2,469,000	**2,480,000**
Venezuela	2,363,588	2,409,066	2,205,195	2,455,545	2,404,477	2,564,234	2,417,054	2,474,385	2,438,207	2,201,782	2,323,150	**2,280,000**
Iran[5]	922,528	766,064	706,120	775,208	750,824	943,864	955,040	876,168	850,212	661,050	920,000[1]	**918,000**
Netherland India: Sumatra	398,988	388,437	377,750	389,439	391,566	409,288	404,756	426,522	420,001	398,651	434,424	**435,476**
Borneo	143,124	135,995	142,549	130,994	143,607	150,752	146,310	149,602	149,741	134,354	146,543	**142,552**
Java[9]	90,460	82,798	78,535	70,387	64,754	70,285	515,160	71,095	71,852	67,576	70,426	**65,210**
Ceram	6,916	6,694	7,253	7,359	6,759	6,771	45,750	6,144	6,604	7,412	8,634	**10,615**
Roumania	568,874	548,139	561,775	556,415	534,475	550,000	525,232	541,884	537,111	496,658	538,719	**520,000**
Mexico[15]	368,886	380,773	425,219	482,171	507,212	491,862	460,025	481,823	367,000[1]	291,000[1]	396,400[1]	**330,400**
Iraq	312,771	355,803	376,415	379,395	351,508	326,086	324,503	312,734	323,797	262,151	360,817	**350,000**
Colombia	253,615	254,514	254,669	260,629	250,475	263,669	259,768	266,046	238,406	229,371	253,663	**250,100**
Trinidad	208,456	201,446	211,113	211,928	213,185	224,385	211,580	234,214	232,537	210,413	229,306	**220,717**
Argentina[1]	196,900	191,900	192,200	193,800	193,500	194,000	193,500	288,930	285,000	184,000	190,000[1]	**188,000**
Peru[3]	178,010	172,745	168,725	176,006	167,718	177,893	172,805	175,667	166,281	146,286	159,774	**159,000**
Bahrein[6]	84,723	90,435	95,428	97,279	97,479	96,660	83,585	85,009	88,264	83,180	89,811	**85,920**
Burma[7]	92,275	93,797	90,309	88,068	86,101	83,548	81,634	89,985	89,100[1]	70,000[1]	90,000[1]	**87,800**
Canada[2]	71,511	67,934	87,586	103,298	111,686	86,545	56,280	61,812	67,151	45,000	70,000[1]	**86,000**
Brunei[8]	58,416	55,552	59,464	58,772	62,688	62,607	63,491	66,939	66,410	59,474	65,749	**62,271**
Great Germany: Old Reich[14]	47,485	47,075	49,897	45,007	47,256	47,788	45,865	45,111	47,562	47,614	56,654	**50,500**
Ostmark[18]	4,900	5,800[1]	4,634	4,394	3,994	6,519	5,600[1]	5,111	5,014	6,962	6,454	**6,100**
Slovakia	1,601	1,484	1,521	1,609	1,597	2,008	1,534	1,443	1,545	1,500[1]	1,500[1]	**1,600**
Poland	42,850	41,607	41,000[1]	43,287	42,366	43,590	42,000[1]	42,688	43,819	38,000[1]	43,000[1]	**41,000**
Japan[10]	30,750	30,839	30,839	30,955	24,277	31,376	31,913	24,724	32,003	31,094	31,631	**30,700**
British India[11]	27,357	26,599	33,300	31,174	29,968	29,054	27,322	30,045	27,000[1]	18,000[1]	33,000[1]	**30,000**
Ecuador	27,004	26,743	27,262	27,412	26,791	27,310	26,314	27,336	27,715	24,325	23,986	**23,190**
Saudi Arabia	492	451	460	453	5,498	18,570	20,697	18,590	21,100	23,169	29,190	**31,821**
Sarawak[12]	18,072	17,340	17,309	13,913	16,191	16,150	15,204	15,540	15,214	13,862	15,838	**14,197**
Egypt[13]	12,642	12,151	11,924	20,583	22,521	29,789	30,285	31,617	44,390	43,045	47,193	**46,897**
Italian Empire: Albania[16]	6,200	10,790	6,873	746	10,247	Nil	Nil	41,674	14,869	10,179	18,801	**12,000**
Italy	1,188	1,074	1,164	1,125	1,027	1,071	1,060	986	933	1,005	1,034	**1,000**
France	6,798	6,048	6,102	6,000[1]	5,756	5,923	5,713	6,000[1]	5,900[1]	5,500[1]	6,000[1]	**5,700**
Hungary	2,418	3,366	3,349	4,000[1]	4,947	6,400[1]	5,602	6,167	6,000[1]	5,000[1]	7,000[1]	**6,100**
Bolivia[1]	1,130	1,100	1,200	1,160	1,000	1,100	1,000	1,130	1,100	900	1,000	**1,000**
Other Countries[17]	850	830	850	850	7,000	6,700	7,000	6,700	7,000	6,000	7,000	**6,700**
WORLD TOTAL	22,320,582	21,770,972	22,714,595	23,589,804	22,178,931	23,353,817	22,892,888	23,099,714	22,905,212	21,077,456	23,591,374	**23,115,566**

[10] Japanese Sakhalin, Taiwan (Formosa) and Hokkaido included with Japan.
[11] Excluding Burma.
[12] Sarawak Oilfields, Ltd., figures.
[13] Anglo-Egyptian Oilfields, Ltd., figures.
[14] Prussia, Thuringia and Baden.
[18] Formerly known as Austria.
[16] Italian imports of Albanian crude oil.
[17] Nominal figure representing proportion to world total represented by: Morocco, Cuba, New Zealand, Barbados, Greece, Algeria, Yugoslavia, Australia, Great Britain, Kuweit and China.
[15] Official Figures—Petroleos Mexicanos.

Official Crude Oil Production Figures for 1932 to 1938 (Revised) in Metric Tons

	Daily Av. Jan.-Apr. 1939	Daily Av. Jan.-Apr. 1938	Jan.-Apr. 1939	Jan.-Apr. 1938	Daily Av. 1938	Total 1938	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**459,236**	454,140	**55,108,294**	54,496,771	447,202	163,228,715	172,822,797	148,707,864	134,912,143	122,913,903	122,601,191	106,289,292
Soviet Union	**81,091**	79,175	**9,731,000**	9,501,000	79,066	28,859,000	27,867,025‡	27,384,900	25,241,100	24,092,700	21,330,100	21,389,300
Venezuela	**77,026**	71,265	**9,243,139**	8,551,742	76,288	27,845,286	27,733,926	22,945,299	21,990,373	20,112,115	17,293,193	17,085,334
Iran	**27,910**	30,525	**3,349,262**	3,663,079	28,379	10,358,495	10,330,480	8,329,289	7,607,500	7,657,970	7,200,093	6,548,941
Netherland India: Sumatra	**14,071**	12,984	**1,688,552**	1,475,804	12,775	4,662,836	4,490,137	4,114,710	3,759,006	3,535,035	2,999,352	2,492,742
Borneo	**4,776**	4,813	**573,190**	577,551	4,712	1,719,783	1,739,607	1,773,545	1,815,998	1,924,234	2,013,849	2,043,707
Java	**2,292**	2,809	**275,064**	337,049	2,559	933,595	960,125	499,097	464,757	510,320	483,331	515,187
Ceram	**277**	230	**33,265**	27,604	224	81,560	72,139	50,446	41,862	36,738	38,300	41,605
Roumania	**17,437**	18,340	**2,092,488**	2,200,749	18,090	6,603,000	7,153,000	8,704,000	8,394,000	8,473,355	7,387,000	7,350,321
Mexico	**11,540**	17,654	**1,384,800**	2,118,453	15,662	5,716,423	6,896,657‡	6,090,842	5,973,955	5,666,857	5,049,109	4,870,175
Iraq	**10,806**	10,993	**1,296,765**	1,319,140	11,904	4,345,000	4,126,185‡	4,079,066	3,724,231	1,048,108	147,943	118,887
Colombia	**8,096**	8,464	**971,540**	1,015,673	8,241	3,007,935	2,844,251‡	2,614,092	2,452,635	2,416,432	1,833,606	2,287,835
Trinidad	**7,441**	6,497	**892,973**	779,636	6,748	2,462,943	2,181,676	1,862,796	1,642,446	1,533,122	1,345,532	1,425,009
Argentina	**7,058**	6,418	**847,000**	770,100	6,665	2,432,857	2,330,063	2,202,304	2,036,903	1,997,706	1,950,499	1,871,882
Peru	**5,261**	5,919	**631,341**	710,316	5,753	2,099,885	2,313,691	2,331,454	2,260,903	2,161,990	1,756,867	1,311,856
Bahrein	**2,810**	3,333	**347,175**	399,926	3,098	1,130,734	1,058,557	635,555	173,072	39,008	4,293	123
Burma	**2,807**	2,783	**336,900**	333,921	2,849	1,039,960	1,083,391	1,047,593	991,456	1,004,951	982,233	976,589
Canada	**2,234**	1,911	**268,151**	229,364	2,400	876,016	378,430	190,495	182,820	178,233	144,686	131,937
Brunei	**2,116**	1,826	**253,904**	219,194	1,937	707,123	576,545	470,991	471,842	386,478	290,808	171,432
Great Germany: Old Reich	**1,686**	1,472	**202,330**	176,590	1,513	552,074	453,451	444,600	427,400	317,500	238,600	229,700
Ostmark	**204**	188	**24,530**	22,516	174	63,468	33,010	7,473	6,616	4,172	860	120
Slovakia	**51**	54	**6,145**	6,485	52	19,282	17,936	18,665	19,946	25,971	17,776	18,493
Poland	**1,382**	1,380	**165,819**	165,568	1,383	504,678	501,301	510,630	614,760	529,200	550,670	556,680
Japan	**1,045**	1,005	**125,428**	120,655	976	356,328	341,040	341,976	326,580	266,520	212,667	239,567
British India	**900**	832	**108,000**	99,848	882	322,125	298,450	273,137	281,072	265,341	224,879	240,767
Ecuador	**827**	860	**99,216**	103,181	876	319,877	306,326	275,293	245,434	231,947	229,578	226,423
Saudi Arabia	**877**	12	**105,280**	1,472	183	66,683	8,070	2,447	Nil	Nil	Nil	Nil
Sarawak	**493**	587	**59,111**	70,407	548	200,126	217,085	221,126	253,799	277,513	315,259	332,819
Egypt	**1,513**	430	**181,525**	51,546	611	223,058	166,298	177,491	176,436	214,671	232,437	265,055
Italian Empire: Albania	**465**	201	**55,849**	24,110	179	65,313	56,760	32,760	6,152	2,500	1,707	1,375
Italy	**33**	37	**3,972**	4,483	36	13,178	14,000	16,106	15,977	20,180	26,526	27,046
France	**192**	196	**23,100**	23,502	198	72,106	71,008	74,788	74,172	98,025	110,120	105,758
Hungary	**201**	60	**24,100**	7,188	120	42,798	13,910	13	Nil	Nil	Nil	Nil
Bolivia	**33**	37	**4,000**	4,442	36	13,262	15,487	13,197	20,540	19,858	14,085	5,284
Other Countries	**222**	28	**26,700**	3,300	93	34,080	10,000	5,300	4,600	9,100	7,700	10,500
WORLD TOTAL	**754,409**	747,458	**90,539,908**	89,612,365	742,412	270,979,582	279,495,814	240,539,340	226,410,486	207,970,753	197,024,849	179,181,741

International Reports

W. G. Skelly, center, discusses the exposition with Alf G. Heggem, left, and Frank J. Hinderliter.

YACIMIENTOS Petroliferos Fiscales (Argentine Government Oilfields) produced slightly over 13 percent more petroleum in 1938 than during the previous year, or 8,998,468 bbl. compared with 7,437,338 bbl. The largest relative increase was in the Mendoza region, where production rose from 86,563 bbl. to 183,499 bbl., while the only decline was a slight one at Plaza Huincul.

A NEW International building which would serve as headquarters for overseas delegates to the show, and as a building in which all oil producing countries would be invited to display relief maps of their oil development, is announced for the May 18th to 25th, 1940, International Petroleum Exposition in Tulsa, Oklahoma.

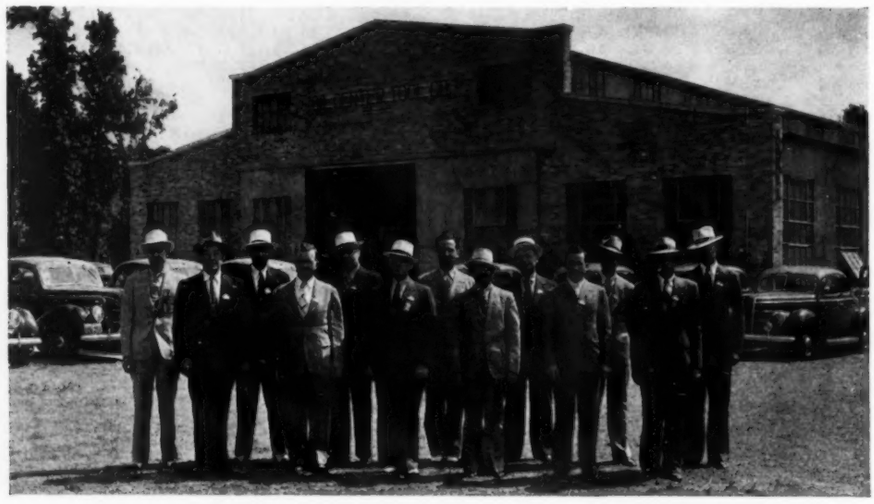
W. G. Skelly will be president of the show again in 1940, and serving with him will be Alf. G. Heggem (president of Oil Well Improvements Co.) and Frank J. Hinderliter (president of Hinderliter Tool Co.) as vice presidents; Clyde H. Pape, secretary-treasurer Selby Oil & Gas Co., treasurer; H. R. Powers (assistant sales manager Bethlehem-International Supply Corp.), secretary; Frank O. Prior (president Stanolind Oil & Gas Co.) and W. M. Bovaird (president Bovaird Supply Co.) executive committee; and general manager Way.

Among the phases of scientific development to be stressed at the next show are: corrosion, measuring depths, use of petroleum substitutes, drilling muds, orientation of drill holes, acids, cracking processes, hydrogenation, temperature control, core analysis, soil analysis. Wherever possible, working models and moving displays will be used.

THE front cover picture of this issue was photographed in natural colors by Cy La Tour and Son; the frontispiece is by Triangle.

THROUGH error the credit line on our front cover for April was omitted—Bayou Choctaw field, photo by John J. Metzger, Jr.

The annual conference of Oil Center Tool Company sales representatives was held during the week of the Oil World Exposition in Houston at the home office of the O-C-T organization. Left to right—(Front) H. D. Start, Houston; H. C. Stewart, Shreveport; B. V. Fisher, Houston; H. S. Perry, Victoria; J. E. Edwards, Houston; Walter Burke, Odessa; (Back) A. J. Penick, Houston; K. T. Penick, Houston; C. J. Hillman, Edinburg; J. R. Mogle, Houston; P. D. Vachon, Corpus Christi; C. K. Mount, Lafayette; and I. C. Wells, Lafayette.



To the Editor of WORLD PETROLEUM

Sir:

I have just had called to my attention Mr. Gabriel's article in WORLD PETROLEUM for December, 1938, on page 41 of which he states:

> "Hawley wrote in 1938 that the use of transients in electrical prospecting helps to evaluate, ' . . . the presence of beds below the electrodes, the depth to a bed being proportional to the time after initiation at which the nick appears and to the resistivity of the region above the bed.' ".

I very much regret that this was published because the conclusion which I reached in this paper from which Mr. Gabriel quoted, was precisely opposite that which was credited to me. For example, I said on page 256 of that article:

> "None of the records obtained in the test area have shown the curves or nicks in the wave front which were postulated in the original description of the method."

I would very much appreciate a correction of the misstatement.

Yours very truly,

PAUL F. HAWLEY

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

GEOLOGY

Geology and Development of Keokuk Pool, Oklahoma—H. L. Pau and K. A. Ackley in BULLETIN AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, vol. 23 (1939), No. 2, pp. 220-245.

The Keokuk pool, which is located in Seminole and Pottawatomie counties, about 10 mi. north of the town of Seminole, Oklahoma, is unique in that it was the first pool in Oklahoma to maintain reservoir pressures through voluntary restriction in the rate of production. It is located in one of the few areas where the Misener sand is of sufficient thickness to afford good reservoir conditions.

The structure of the Keokuk pool is anticlinal and is faulted on the east side. This area was probably affected by at least three periods of structural adjustment, but the one which is probably the chief cause of the faulting and folding in the Keokuk pool occurred in early Pennsylvanian or late Mississippian time.

From 106 wells producing from the Misener sandstone and the Hunton limestone the pool has produced 6,362,224 bbl. of oil to January, 1938. This is equivalent to 60,021 bbl. per well on a basis of 20-acre spacing covering practically all of the productive area. A final recovery of 8,000 bbl. of oil per acre is anticipated.

The original plan of maintaining 20-acre spacing was accomplished by the wells being offset 1,320 ft. each and west. However, after the shape of the structure was determined to be narrow east and west, the spacing was changed to 1,320 ft. north and south instead.

The value of communitization is illustrated in the orderly manner in which the drilling program was carried out and is marked by the few dry holes which were drilled to outline the productive limits of the field.

Communitization has enabled production to be limited, regulated, and controlled so that the highest per-acre recovery may be recovered at the least cost. The benefits derived from this type of operation were recognized by other operators outside of the community plan, who consequently adopted the plan essentially along the same lines.

Geologic Aspects of Heaving Shale in Texas Coastal Plain—J. M. Frost, III, in BULLETIN AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, vol. 23 (1939), No. 2, pp. 212-219.

For many years heaving shale has been of utmost interest because it is the only apparent reason why some of a certain group of structures cannot be explored successfully. The problem of heaving shale is one of the most costly in the drilling of oil wells. Many of the ramifications of the problem have been the subjects of research but the geologic aspects have been studied less thoroughly. Little has been published concerning the geologic phase of heaving shale, and the writer hopes to contribute some information in this respect.

After a thorough search for all fields and wildcat wells where heaving shale has been recorded in the Texas Coastal Plain, it has been found that there are five principal heaving-shale zones: Lower Miocene, Middle Oligocene, Vicksburg, Jackson, and Yegua. These formations form belts or trends parallel with the shore line of the Gulf of Mexico. The downdip limit of each trend cannot be determined as accurately as the updip limit because of the less advanced drilling practices in the past, and because sufficient deep wells drilled downdip are lacking. A map showing the several trends is helpful in determining the probability of encountering heaving shale. A comprehensive bibliography is included.

Stratigraphy and Historical Geology of Gulf Coastal Plain in Vicinity of Harris County, Tex.—Willis C. Meyer, in BULLETIN AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, vol. 23 (1939), No. 2, pp. 145-211.

Since the publication of E. T. Dumble's comprehensive studies of the Tertiary of eastern Texas, a great number of stratigraphic data have been made available by the drilling of thousands of deep oiil wells in the region. Although many admirable papers have been written on the Tertiary of the Texas Gulf Coast since the advent of deep drilling in the area, full advantage has rarely been taken of available subsurface data, with the result that the emphasis, in most cases, has been placed upon surface geology.

The purpose of this investigation is to make a detailed study of the subsurface formations of an area in eastern Texas and to continue the investigation up the regional dip to the outcrop of these formations. By thus emphasizing the subsurface development of the formations, it is hoped to bring about a better understanding of the stratigraphy and historical geology of the area than was previously possible.

A description of all post-Weches formations of the Gulf Coastal Plain in the vicinity of Harris County, Texas, and the geologic history of the Gulf Coastal Plain of southeastern Texas are presented. The many deep wells in this region make it a favored area for such an investigation as the one here attempted. A comparison of surface sections with subsurface sections reveals important changes of facies in nearly every formation.

A geosyncline of major dimensions is located near the outer margin of the Gulf Coastal Plain in eastern Texas and Louisiana. The formation of this geosynclinal depression and the accumulation of sediment in it are the dominant features of the Cenozoic history of this region. Tertiary and Quaternary deposits in the vicinity of Galveston, Texas, are estimated to be 35,000 ft. thick. The origin of this geosynclinal depression is discussed.

DRILLING

Sulphate-Resistant Cement—Svend Rordam and Cedric Willson, in PETROLEUM TECHNOLOGY, vol. 2 (1939), No. 2, T. P. No. 1029; 3 pages.

Corrosive sulphate salts are found in natural ground waters encountered in drilling oil wells in many fields, consequently their effect on the cement slurry used for oil-well cementing comes in for a good deal of consideration.

The best defense against this trouble is a cement of proper composition. It has now been established that a cement having no more than nought to three percent of tricalcium aluminate may be considered practically immune to the attacks of sulphate solutions, but where the tricalcium aluminate content exceeds four to five percent, failures can be expected. The rate of attack on hardened cement slurry is governed to some extent by the concentration of these salts in the water; however, the corrosion is practically at a maximum when the water contains one percent of sodium sulphate or 0.5 percent of magnesium sulphate.

In some recent experiments it has been found that when specimens of 1:3 plastic mortar was exposed to 10 percent sodium solutions at 70 deg. and at 160 deg., the sodium sulphate solution was more destructive on the cement at the lower than at the higher temperature; this is of some importance, because it shows that the need for a sulphate resistant cement is greater when the corrosive waters are encountered in shallow production and lower temperatures than in deep wells where temperatures may be as high as 200 deg. or over. Of course, a cement that is resistant to the attack of sulphate at low temperatures is bound to be even more resistant at the higher temperatures.

Since the active life of an oil well should be from 10 to 40 years the cement job should stand up until the well is exhausted. Hence the importance of choosing the proper cement in areas where ground waters are known to contain destructive sulphate salts.

Diamond Core Drilling in the Pennsylvania Oilfields—Newton C. Williams and Paul M. Philippi, in OIL AND GAS JOURNAL, vol. 37 (1939) No. 36, pp. 34-36; 53.

Two kinds of diamonds, carbons and borts, are used in diamond drill work. The carbons, or black diamonds, which have no cleavage planes and hence are the least likely to split, are used for coring the hardest rocks, while the less tough, semi-transparent borts are used for the softer formations such as sand or shale. An ordinary core drill will carry 10 to 12 diamonds weighing four to five carats each. The average diamond loss, due to wear and breakage in coring, is about $1.00 a foot in the Pennsylvania field.

Diamond core drilling is especially indispensable in all water flooding projects, because it is the only way to obtain accurate information about sand formations, yet there are producers who are willing to

spend many thousands of dollars in development and mechanical equipment and at the same time leave out a thorough knowledge of their sand conditions. The success of a flood property is directly proportional to the oil sand contained within its bounds. No operator can afford to water-flood without first studying the characteristics of his sand exhaustively. Oil content and well spacing, setting of packers, type and size of pumping equipment and the style of flooding equipment, are all dependent on a thorough detailed examination of the sand. How can a producer find out completely about his own particular sand condition? Only by bringing out a solid section of that formation as it exists in the ground.

Shifting of Rigs Cuts Drilling Costs—Claude Johnston, in OIL WEEKLY, vol. 92 (1939), No. 7, pp. 61-62.

The Delta Drilling Co. have inaugurated a somewhat unusual system, about as follows: In a field where contract depths are over 7,700 ft., a light rig is employed to drill the first five or 5-6,000 ft. Then the entire rig, including crown block, traveling block, drawworks and boilers are stripped for transportation and hauled away to a new location. Immediately thereafter a heavier rig is installed over the uncompleted hole and the well is carried on down to the contract depth.

By having locations and derricks ahead, it is possible for two light rigs in the field to keep ahead of the heavier completing units, thus giving, in actual drilling results, the same number of completions as would be secured were all the derricks equipped with the heavy equipment.

The object of this plan is to save on capital investment and maintenance. The heavy rigs are much the more expensive in first cost and in upkeep. By using the cheaper equipment for the easiest part of the job and the heavy equipment for the more difficult part the overall savings are distinctly worth while. In comparison, the time lost in the shift from the light to the heavy rig adds an insignificant cost to the system.

Control of Heaving Shales by Blasting—F. R. Cozzens, in PETROLEUM ENGINEER, vol. 10 (1938), No. 3, p. 46

In certain districts in Ohio, West Virginia and Kentucky the driller encounters waxy, grainless shales that behave much like quicksand, which slip and crumble the moment an opening is made. The thickness ranges from 30 to 70 ft. It is virtually impossible to drill through this shale unless special equipment is used.

The procedure is to drill about 12 ft., then withdraw the drill and lower a torpedo charge with 40 percent ammonia dynamite. Explosion of this charge exerts a compacting pressure on the shale so that it will stand up. Drilling is resumed until more trouble of the sort is experienced, when the blasting is repeated; and so on until the formation has been penetrated and casing is set.

Development and Production Problems in High-Pressure Distillate Pools—E. V. Foran, in PETROLEUM TECHNOLOGY, vol. 2 (1939), No. 1 paper T.P. No. 1023, 9 pages.

A frequent result of recent deep exploratory drilling is the discovery of reservoirs of which the products at the time of discovery exist largely or wholly in the gas phase. Such reservoirs are popularly known as distillate pools. In some places the entire reservoir is filled with the wet gas containing water-white condensible products in the gas phase, for example the 8,200 ft. horizon of the Big Lake field in West Texas, or the distillate-bearing gas may form a large gas cap over an extensive reserve of dark oil. In all cases the formation pressure is high.

An important peculiarity of these distillate pools is that when the pressure declines, the heavier components of the wet gas condense, and may be recovered in an ordinary separator. This property of the wet gas has to be carefully considered in the operation of the distillate pool, because as the pressure drops within the reservoir the liquid products will condense in the sand and are lost. Hence every effort must be made to retard the pressure decline as much as possible. The approved practice is to strip the wet gas and return the dry gas to the reservoir.

Above all other cases, the distillate oil pool requires unitary operation because too rapid a reduction of pressure in one well will also ruin the prospects of remote wells. Wide well spacings (one well to 120 or even 320 acres) and large diameter casings (8⅝ to 9⅝ in.) set on top of the sand are called for.

Typical Oilfield Brine-Conditioning Systems—Sam S. Taylor, C. J. Wilhelm and W. C. Holiman, in BUREAU OF MINES REPORT OF INVESTIGATIONS 3434, January, 1939.

The disposal of oilfield brines by injection into subsurface formations other than fresh-water-bearing strata is a positive method of eliminating the harmful effects of mineralized water on fresh-water supplies, vegetation, and aquatic and other animal life.

The methods used most generally for the disposal of brines produced with oil are (1) impounding in evaporation ponds, (2) controlled diversion into surface streams, and (3) injection into subsurface formations. Various states recognize one or more of the methods as legally authorized procedure. As a general rule, impounding brine in ponds and solar evaporation have not been entirely successful, principally because of the large volumes handled, the porous nature of the soil, and the low rate of evaporation. Likewise, the diversion of brine into freshwater streams by controlled dilution has not proved satisfactory in some areas, especially in parts of Kansas and Oklahoma where the rainfall is relatively low, because it has been impossible to obtain enough fresh water for such dilution.

This report describes in great detail five systems of returning salt brines to formation now used in Kansas, with particular emphasis on the preparation of the brine for subsurface injection. The brines require special handling according to whether they are saturated or undersaturated with carbonates, alkaline, acid or sulphide-containing. This report should be consulted by all petroleum engineers who have brine-disposal problems where subsurface injection is feasible.

REFINING

Hydrogen Sulphide Removal System—J. M. Mullen, in PETROLEUM WORLD (Calif.), vol. 36 (1939), No. 3, pp. 63; 80-82.

In the new Richfield Oil Company refinery at Watson (Calif.) hydrogen sulphide in gas from the gasoline stabilizer unit is reduced from 2,000 or more grains per 100 cu. ft. to less than 100 grains by the tripotassium phosphate process. The plant is simple in design and operation.

Absorption is accomplished principally according to the reaction

$$K_3PO_4+H_2S—K_2HPO_4+KHS$$

The reaction is reversed during regeneration. Mercaptans are not removed by the phosphate process. Ammonia, when present, is absorbed by the solution and is driven off along with the hydrogen sulphide. Gases enter the absorber at the bottom, rise through 36 bubble plates countercurrent to a stream of descending absorbent solution, and pass out at the top. The absorbent is tripotassium phosphate solution containing 2.0 gram mols K_3PO_4 per kilogram of solution. It is mixed at the site from steam condensate and commercial grades of potassium hydroxide and phosphoric acid in such proportion that the mol ratio of KOH to H_3PO_4 is between 2.95 and 3.00 to one. From the absorber the foul solution is released by level control to the regenerator. Regeneration is accomplished by concentrating the solution in a standard steam heated boiler. The concentrated solution falls to a surge tank where the solution pump picks up the regenerated solution and pumps it back to the absorber by way of the heat exchangers and a solution cooler. Vapors, hydrogen sulphide and steam, pass overhead from the reboiler to a condensate stripper, H_2S goes overhead to a waste products burner. Stripped condensate is returned to the top of the absorber by the condensate pump.

This plant utilizes one interesting feature of the phosphate system. The equilibrium solution saturation, expressed as mols H_2S per mol K_3PO_4, corresponding to a given concentration of H_2S in the hydrocarbon, is greater for a dilute solution than for a more concentrated one. Advantage is taken of this fact by doing the bulk of the stripping with a concentrated solution in the lower section of the absorber and using a dilute solution to remove the last traces of H_2S in the upper section. The dilute solution is made up of all the condensate and a portion of the regenerated K_3PO_4 measured by a rotameter.

Catalytic Polymerization and Copper Sweetening—J. C. Albright, in REFINER, vol. 18 (1939), No. 3, pp. 91-95.

A new catalytic polymerization plant is being operated by the Sunray Oil Co. to process 800,000 cu. ft. of gas a day as a peak load. The feed to the plant is a mixture of about 50 percent raw stabilizer gas and 50 percent polymer stabilizer overhead discard, and contains an average of about 20 percent of available olefins. The results obtained so far have been of the order of 95 percent conversion of olefins. The production of gasoline amounts to about 3,500 gal. a day when the pressure distillate is stabilized to five pounds Reid vapor pressure, assuming that the cracking plant produces 550,000 cu. ft. of gas which has an olefin content of 35 percent.

The product is doctored by the copper treating system and caustic-washed to remove hydrogen sulphide.

Effect of Hydrogen Peroxide in the Regeneration of Spent Doctor Solutions—Virden W. Wilson, in REFINER, vol. 18 (1939), No. 3, pp. 96-100.

The economics of the doctor methods of sweetening gasoline by the plumbite process depends largely on the reconversion of lead sulphide to litharge, which is usually done by air oxidation in the presence of caustic soda.

In a series of investigations on the improvement of present doctor reclamation processes, it has been found that the addition of a small quantity of concentrated hydrogen peroxide together with air at the outset of the normal air reclamation would improve greatly the reclamation characteristics of the doctor solution. The introduction of the hydrogen peroxide may be accomplished in a variety of ways but it is important that the peroxide be added uniformly and contacted with as much of the spent solution as possible. The quantity of hydrogen peroxide to be added varies with the characterictics of the spent doctor; it appears to be an empirical function related to the total quantity of lead (either oxide or sulphide) present in the spent doctor, the age of the doctor solution (and consequently the non-reactive

solids content) and the desired soluble lead content of the reclaimed plumbite solution. The results obtained by the use of hydrogen peroxide are such as to justify economically the application of this oxidizing agent as a promoter for the reclamation reaction. The process has in the meantime, been demonstrated to have excellent economic value.

The mechanism of the promoter reaction of hydrogen peroxide is believed to be twofold: first, there is undoubtedly some reaction directly between the nascent oxygen released on decomposition of the peroxide, and the lead sulphide of the spent doctor solution; second, there is a promoter or catalytic reaction in which the hydrogen peroxide acts upon some other substance present in the spent doctor, in such a way as to activate the solution so that subsequent air blowing results in rapid, clean conversion of the lead sulphide to soluble litharge.

The operating figures given by the author show that the hydrogen peroxide-air reclamation method nearly doubles the recovery of lead oxide. On a volume of about 10,000 gal. of spent doctor solution the extra recovery of litharge is about 200 lb.

Catalytic Effect of Metals on Paraffin Hydrocarbons—C. L. Thomas, G. Egloff and J. C. Morell, before AMERICAN CHEMICAL SOCIETY, Baltimore Meeting, April, 1939.

This review assembles existing information on the action of common and rare metals as catalysts of petroleum.

It is a curious fact that iron and its simple alloys, which are most extensively used in refinery construction, have powerful catalytic effects on petroleum, yet crude oils can be satisfactorily cracked in iron and steel equipment with no evidence of the complete decomposition to the soot-like catalytic carbon. As a matter of fact a tube in a cracking coil builds up a hard, dense liner of carbon which is in direct contrast to the catalytic carbon. Thus in the laboratory, using pure compounds, one result is obtained while in commercial practice using a mixture a different result is obtained. It is natural to attribute the difference to some of the other components of the mixture. In view of their experience of poisoning the catalytic activity of 18-8 chrome-nickel steel with hydrogen sulphide the authors are inclined to the theory that the sulphur compounds in commercial charging stocks form a film of inert iron sulphide on the interior of the tube permitting the deposition of the hard, dense carbon liner. This theory finds some support in the well-known observation that sulphur compounds are powerful poisons for iron, nickel, and cobalt catalysts for other reactions.

Sulphur compounds are not the only possible poisons for this activity of iron. Both steam and carbon dioxide can react with iron to form a strongly adhering film of Fe_3O_4 that seems to prevent further activity of the iron.

Thus it seems quite likely that petroleum cracking in steel equipment is possible because some constituent of the petroleum acts on the iron to destroy its catalytic activity and prevent the formation of the catalytic carbon that would be expected from the results obtained with pure compounds.

CHEMISTRY

Mineral Oil Deterioration—A. G. Asaf and E. K. Gladding, in INDUSTRIAL ENGINEERING CHEMISTRY, vol. 11 (1939) No. 3, 164-166.

The deterioration of mineral oil is due primarily to the action of oxygen, which gives rise to the formation of ketones, esters and peroxides which show themselves as gum or sludge.

In the last few years the Grignard reagent has been recognized as a means of quantitatively estimating these substances and it has been applied with success to measure the ageing of mineral oils. The authors report the results of an investigation into the sensitiveness of the Grignard reaction when used for this purpose. They obtained the following figures:

	Moles of CH_3MgI per Mole of Compound			
Compound	Evolved	Added	Consumed	Theoretical
Benzophenone	None	1.04	1.04	1.00
Phenyl benzoate	None	1.92	1.92	2.00
"Ester gum"	3.7	2.4	6.1	6.0
Decalin peroxide	0.96	1.07	2.03	2.00

The solvent used was xylene. The figures show good agreement. An improved apparatus for making the analysis is described.

Production of High Octane Isoparaffinic Fuels by Addition of Olefins to Isoparaffins—S. F. Birch and others, before AMERICAN CHEMICAL SOCIETY, Baltimore Meeting, April, 1939.

The sulphuric acid catalyzed addition of C_4 olefins to isobutane enables a saturated material, essentially isoparaffinic and possessing a high octane number, to be obtained in one stage without recourse to polymerization or hydrogenation. Under favorable conditions more than 70 percent of the product consists of isooctanes formed by direct addition and isomerization. Apart from neutralization and distillation to remove excess isobutane and a comparatively small amount of high-boiling material, no further treatment is necessary to obtain a suitable component for high octane aviation fuels.

Of the acid condensation reactions examined, apart from those involving the addition of butenes and their polymers to isobutane, those of most promise technically appear to be the addition of propylene and isobutane and butenes with isopentane. Both reactions, under favorable conditions, give excellent yelds of high octane gasoline in which the direct addition product and its isomers predominate. Thus, while the former consists largely of isoheptanes boiling within the range 80 to 90 deg. C., the product from the latter consists substantially of isononanes, particularly 2.2.5-trimethylhexane which has an octane number of 91.6.

In general, the acid requirements for reactions involving propylene or isopentane are appreciably higher than for the butene-isobutane addition. While this is not surprising with propylene, which forms comparatively stable sulfuric esters, it is less easily explained with isopentane. The technical development of these reactions must therefore await reduction in their acid requirements. The separation of highly unsaturated oils on dilution of the used acid with water characterises all these reactions. These oils are similar in properties to those previously described in connection with the diisobutene-isobutane reaction and are presumably products of hydropolymerization.

Suppression of Metal Catalysis in Gasoline Gum Formation—F. B. Downing, R. G. Clarkson and C. J. Pederson, before AMERICAN CHEMICAL SOCIETY, Baltimore Meeting, April, 1939.

The formation of gum in gasoline is an oxidation process which is promoted and accelerated by the presence in the gasoline of certain organic catalysts, which are generally considered to be peroxides or moloxides. Cracked gasolines are especially liable to this autogenous oxidation or gum formation.

In recent years, however, great success has followed the introduction of gum inhibitors that paralyze the action of the gum-forming catalysts; many of these gum inhibitors are available.

It now appears that the favorable action of a gum inhibitor may itself be paralyzed by an extraneous catalyst, so that an inhibitor-treated cracked gasoline may gum as rapidly as if no inhibitor had been added. Among these pro-oxidant or anti-inhibiting catalysts are various metals, particularly copper. The crude petroleum itself frequently contains traces of metals. Conduits and containers made of copper and its alloys are used for storage or transportation, and the use of copper salts for sweetening gasoline is increasing. And it is well recognized that copper sweetening gasoline is increasing. And it is well recognized that copper sweetened gasoline is susceptible to rapid discoloration, gum formation and development of malodorous products unless the residual copper is removed. Removal of residual copper by chemical means does not always completely restore the natural non-oxidizing quality of the original gasoline, and the gasoline is not protected from future contamination.

The point is that the natural anti-oxidants of the gasoline and the pro-oxidation metal catalysts are mutually antagonistic and their joint presence leaves the gasoline susceptible to gumming.

A remedy for this situation has been found by adding to the gasoline a third catalyst which will paralyze the catalytic action of the metals. Such a deactivator of metal oxidants is found in disalicylal ethylene diamine, which is made by condensing two molecules of salicyl aldehyde with a molecule of ethylene diamine, which is soluble in gasoline and resists extraction by water.

This copper deactivator completely eliminates the effect of copper that finds its way into gasoline. For instance, when 0.001 percent of one of the gum inhibitors most used at present (p-benzyl-aminophenol) was added to a gasoline the induction period was 270 minutes; addition of one part per million of copper reduced this period to 45 minutes in spite of the inhibitor; when one p.p.m. each of copper and the copper deactivator were added along with the inhibitor to the gasoline the induction period was raised to 430 minutes. That is, the deactivator enhanced the anti-gumming effect of the inhibitor. This was found to be true of all the common organic gasoline anti-oxidants. It is shown that use of the deactivator greatly decreases the quantity of organic inhibitor required for stabilizing copper-contaminated gasoline. In some gasolines the deactivator alone will markedly increase the induction period.

It is considered difficult to keep refinery gasoline from contamination by copper, as tests on commercial goods have shown.

ASPHALT & TAR

Asphalt Formation by Air Oxidation of Heavy Oil Distillates—H. Kamptner and W. Maass, in PETROLEUM ZEITSCHRIFT, vol. 34 (1938), Nos. 51-52, pp. 6-14.

Heavy distillates from naphthenic, paraffinic and asphaltic crude oils were heated to 180 deg. to 190 deg. C. for 76,61 and 91 hours, during which times 28,700, 23,000 and 34,000 liters of air were passed through the oils (8 kg. samples in all cases). The naphthenic and paraffinic base oils gave a precipitate of granular asphalt containing free carbon; the distillate from the asphaltic base oil was thick and homogeneous at the end of the treatment.

The asphaltizing process is supposed to proceed as follows: resin is formed from the oily constituents, which is transformed into hard asphalt; in the naphthenic and paraffinic base distillates a part of this hard asphalt is transformed into free carbon. A characteristic stage appeared in all cases at the end of 40 hours, when soft asphalt disappeared entirely; it thus appears that the soft asphalt is particularly sensitive, and with further asphaltizing is transformed into hard asphalt and free carbon. If it is true (as assumed by Pfeiffer and van Doormaal) that good peptization of asphaltenes requires the

presence of aromatic and hydroaromatic hydrocarbons, then it must be supposed that such compounds are extensively removed from naphthenic and paraffinic distillates during air-blowing; the remaining hydrocarbons are not able to keep the asphaltenes in solution, so they are precipitated. On the other hand it seems that the asphalt-base distillates must contain a large reserve of aromatics and hydroaromatics.

Solvent Extraction of Bituminous Rocks—Ed. M. Salerni, in REVISTA ITALIANA PETROLEO, vol. 7 (1939), No. 7, pp. 3-10.

An outline is given of a process which, when applied to bituminous rock found in Italy, is expected to increase the country's supply of liquid fuels by 25 percent. The process as outlined involves crushing the material to a coarse powder (2 to 5 mm.) which is preheated to about 80 deg. C. and extracted in counter-current by a mineral oil (boiling range 180 deg.-260 deg. C.) also heated to the same temperature. About 10 minutes are allowed for the powdered material to pass through the extractors, the current of oil having a velocity sufficient to carry with it the fine dust; the coarser material is filtered and steam-distilled to recover the adhering solvent and other values; the extract is freed from suspended fine material by filtration and is fractionated. All operations are more or less automatic. Costs for power and heat are said to be reasonable in view of yields and market conditions in Italy.

Some Asphalts from Oregon (Wyoming) Basin—K. E. Stanfield, in BUREAU OF MINES REPORT OF INVESTIGATIONS NO. 3435, March, 1939.

A glass distilling apparatus is described and a method of procedure given for reducing asphaltic crude oil to asphalt. This is done by topping the crude oil at atmospheric pressure and then removing the heavier distillates at 2 to 3 mm. mercury absolute pressure. The asphalts obtained by this procedure are uncracked if the reduction is discontinued at or below the initial cracking temperature of the crude oil indicated by the formation of light distillate and increased amounts of noncondensible gases.

Six penetration asphalts were prepared from Oregon Basin (Wyoming) black oil and their properties determined by common asphalt tests. According to these tests, the asphalts compare favorably with similar asphalts from other crude oils and meet the usual specifications for penetration asphalts.

USE

Dielectric Stability of Mineral-Oil-Treated Insulation; Influence of Chemical Factors—F. M. Clark, in INDUSTRIAL ENGINEERING CHEMISTRY, vol. 31 (1939), No. 2, pp. 327-333.

The dielectric stability of mineral-oil-treated insulation is greatly influenced by the susceptibility of the mineral oil to oxidation. The beaker oxidation test, however, is not a proper gage of the suitability of a mineral oil for impregnation use. Such tests fail to give data concerning the reactivity of the oxidation-formed products, the effect of high-voltage stress on their formation, and their ability to disperse through and to be absorbed by the cellulosic insulation.

The ability of oil-treated cellulosic insulation to resist dangerous oxidation effects is best determined by an examination of the power factor of the treated paper as affected by a voltage life test. A suggested test is carried out at 75 deg. C.; the surface of the impregnating oil in which the test specimen is immersed is exposed to air.

To obtain the highest degree of dielectric stability in Gulf Coast mineral-oil-treated cellulosic insulation, the impregnating oil should contain a minimum of olefinic unsaturated, oil-soluble compounds and a restricted amount of aromatic unsaturated compounds of the type normally present in the crude oil. For the Gulf Coast type of mineral oil used, the optimum amount of aromatic unsaturated compounds should be between approximately four and eight percent.

Oil-soluble contaminants in the mineral oil may produce abnormally high initial power factor values for the treated insulation. Equally dangerous effects, however, are produced by those oil-soluble contaminants, the presence of which has little effect on the initial power factor but which contributes to insulation instability during the high-voltage use of the treated dielectric. Such a material is stearic acid.

Completely saturated paraffin hydrocarbon mixtures are not suited for high-voltage dielectric use.

The addition of pure aromatic hydrocarbons of the benzenoid type to mineral oils in order to reduce gas evolution under electric discharge is limited by the effect of such materials on the dielectric stability of the treated insulation. Paraffinic carbon chains in the molecule of the aromatic addition must be avoided.

Journal Lubrication—J. E. Hedrick and R. R. Freeman, in REFINER, vol. 18 (1939), No. 3, pp. 101-106.

The modern trend in the use of most machinery is toward smaller, lighter and faster equipment. This calls for higher speeds and greater loads on bearings which must at the same time be reduced in size. Automotive and aircraft engines are good present-day examples. Yet the wear and the power loss due to friction through the use of these bearings must not be excessive. In fact it should be reduced. These requirements mean that the bearings must operate under conditions where factors other than the viscosity of the lubricant become important.

The authors experimented on the effects of certain additions to lubricating oil to lower the friction coefficient and to increase the seizure load, that is, the load under which the oil film becomes so thin that the metal of the journal and bearing come into rubbing contact.

The load required to break the oil film is increased when 2-4-6 trichlorophenol is added to the plain oil, while dichloromethylstearate increases the ability of the oil to maintain loads up to the limit of the apparatus used. However, the dichloromethylstearate causes more wear than the plain oil, while the 2-4-6 trichlorophenol causes less wear than the plain oil. These results hold only for steel on steel; it is probable that different results might be obtained with other metals.

The Varnish Problem—Symposium, NATIONAL PETROLEUM NEWS, vol. 31 (1939), No. 8, pp. 25-26; 28-29.

In spite of the fact that motor oils of today are better than ever, it is noted that varnish-like deposits are formed on moving parts of the modern automobile engine. According to ten experts who have contributed their opinions on the subject, this condition will occur at temperatures of 250 deg. F. and above with practically any kind of mineral lubricating oil, provided the time of service is long enough; some oils will varnish in 25 to 30 hours and the best oils in 50 to 60 hours of service. Renewed attention is called to the subject, because some of the newer engines run hotter, the clearance between moving parts is smaller, and oil films are thinner on hot surfaces and more subject to oxidation. The result is a likelihood of scored bearing surfaces, stuck rings and other troubles. In so far as these troubles have increased in the newer engines it can hardly be blamed on the oil, because motor oils are generally better in quality than ever before. The fault if any lies with the engine designers who overlook the fact that engine designs which appear theoretically desirable, may prove more or less defective in view of other factors involved in practical engine operation.

However, the consensus obviously is that the motorist, by taking sufficient pains, can mitigate the trouble by changing his oil more frequently and keeping his radiator in good condition so that the temperature of the oil in the crackcase will not exceed about 260 deg. F.

Miniature Penetrometer for Determining the Consistency of Lubricating Greases—Gus Kaufman, W. J. Finn, and R. J. Harrington, in INDUSTRIAL ENGINEERING CHEMISTRY, Analytical edition, vol. 11 (1939), No. 2, pp. 108-110.

The accepted method for determining consistencies of lubricating greases is the A.S.T.M. method which requires that a considerable quantity of grease be available—i.e., at least 400 to 500 gr. for grease of soft or moderately soft consistencies. Such large quantities of grease are readily obtainable in the manufacturing plants or in storage; however, it frequently happens that information on the consistencies of small samples of grease is desired. After use on ball or roller bearings, such as the antifriction bearings of motors, automobile wheels, industrial machines, etc., only relatively small quantities of worked or used grease adhere to the bearings. This amount of used grease is inadequate for actual measurements of consistency by the A. S. T. M. method; hence, it has been the usual custom to estimate consistency change in use more or less by guess or by comparison with products of known consistency. The accuracy of such practice is, of course, questionable.

The authors describe a small, inexpensive apparatus which can be used to obtain penetrations on small samples of the order of four grams of grease which gives results of reasonable reproducibility. It utilizes the present A.S.T.M. penetrometer and requires in addition only a simple constructed grease holder and an aluminum plunger and cone.

The Day-Degree in Oil Heating—Andre Minne, in REVUE COMBUSTIBLES LIQUIDES, Vol. 17, (1939), No. 161, pp. 8-10.

Oil heating equipment in several apartment houses was equipped with thermostats, and thermometers for registering outside and inside temperatures, and consumption of fuel oil per day-degree was computed (a day-degree is one degree of average temperature above or below an assumed standard temperature, figured on a 24 hour average). For the month of November the relation of outside temperatures to oil consumption was as follows:

Outside temperature in deg. C.	Oil Consumption per day-degree, liters.
3.5	20.5
7.0	27.5
9.5	22.0
10.5	55.0
14.0	60.0
14.7	75.0

The inside temperature was kept close to 20 deg. C. (68 deg. F.) From these figures it appears clear that it costs more proportionally to heat a house in mild than in cold weather. This suggests that instead of a single boiler to heat a large apartment it would be better to use two of the same total capacity but of unequal sizes.

Investigation of Insulating Oil Deterioration—J. C. Balsbaugh and J. L. Oncley in INDUSTRIAL ENGINEERING CHEMISTRY, vol. 31 (1939), No. 2, pp. 318-326.

For the particular application of insulating oil to impregnated paper insulated cables some of the properties of importance are:

a. Physical properties such as viscosity, set point, coefficient of expansion, and surface tension. These physical properties are determined by both manufacturing and operating conditions. For example, with solid-type cables the physical properties are important in determining oil migration and void formation due to temperature variations under load cycles.

b. High stability to deterioration, such as might be caused by oxidation or the influence of heat in the presence of materials in contact with the oil under service conditions or manufacture. An important criterion of this stability is the resultant increase in power factor of the oil and of the impregnated paper.

c. High stability to gas evolution and wax formation under electrical discharge, such as might be caused by ionization in voids formed in the insulation under service conditions.

d. High stability to electric stress.

The relative importance of *a*, *b*, *c*, and *d* depend upon whether the cable is of the solid or oil-filled type. For example, *b* is more important in the oil-filled than in the solid type, and *c* is more important in the solid than in the oil-filled type.

The oils used in this study include two products manufactured from crude petroleum and three synthetic hydrocarbons (cetane, decalin, and tetralin). The oxidizability of these oils was determined and found to vary over a wide range. The Grignard test is found to be a valuable tool for revealing total oxidation products and the active hydrogen in an oil.

It is noted that the synthetic hydrocarbons had much lower dielectric losses for a given amount of chemical deterioration than the other oils; in all cases the dielectric losses are due almost entirely to ionic conduction (within the conditions studied).

Oils with an unusually large ratio of dielectric constant to density generally exhibit a rapid rate of deterioration when subjected to oxidation.

Light transmission measurements over the entire visible portion of the spectrum are reported in the hope that such a study may reveal the nature of certain deterioration products.

ECONOMICS

Economic Equilibrium in Petroleum Refining Operations—Norman D. FitzGerald, in PETROLEUM TECHNOLOGY, vol. 2 (1939), No. 1. T. P. No. 1030; 15 pages.

From a study of petroleum statistics east of California over a period from January, 1930, to September, 1938, certain definite economic phenomena came to light.

One of these is that there is a lag of from three to six months in the conformity of the total demand for petroleum products with general industrial production. In other words, increase in demand for oil products trails behind increase in general business.

Again, there is a persistent lag of from 12 to 15 mos. in the conformity of inventories of petroleum products with general industrial production. This is strikingly shown by the substantial increase in the storage of products during 1937 and the first half of 1938, whereas industrial production reached a peak in December, 1936, and demand for oil products attained its high point in September, 1937. In other words, the oil industry did not reduce its operations sufficiently to commence liquidation of its excessive inventories of products until more than 17 mos. had elapsed from the top in industrial activity. Inventories, instead of reflecting business conditions, are a full year behind, thus accentuating swings in the petroleum economy.

These findings are summed up in the statement that inventories of petroleum products of any particular month appear to reflect the influence of total demand of the twelfth preceding month, the level of industrial activity of the seventeenth preceding month and the current volume of crude oil in storage.

The moral of this situation is that the economics of the oil industry are less well understood than might be the case if management were somewhat more given to looking ahead.

Despite the fact that the oil industry has one of the best and most complete statistical registers among our major industries, it appears to give little attention to the management of inventories of products until the problem becomes acute and important price changes have been induced. This difficulty could be mitigated if the current supply of products were adjusted to the near future level of demand, rather than to shipments of the recent past. Then the lag in the adjustment of inventories to demand would be reduced and swings in prices minimized by the maintenance of a better over-all balance.

An unusual opportunity is afforded in anticipating changes in requirements because shipments of petroleum products appear to lag industrial production by more than three months. Seasonal shipments induce wide movements in the storage of particular products, but the complementary nature of their requirements permits efficient operation with a relatively constant over-all inventory. An effort should be made to counteract the present tendency of excessive supplies to be produced for several months after a decrease in demand with its resulting inventory increases. Care should also be exercised to avoid an expansion of inventories based upon abnormal or erratic demands as contrasted with wise increases based upon stable advances in shipments.

Benefits of Proration—Ernest O. Thompson, in OIL WEEKLY, vol. 93 (1939), No. 2, p. 13.

The discovery of oil has recently gone forward at a rapid rate. In 1938, 91 new fields were discovered in Texas and 12,000 new wells were drilled; yet there is now less production than during the year before, because proration has held the new oil back about 10,000 bbl. under the market demand, even in spite of the unprorated new production of 160,000 bbl. a day in Illinois.

The author credits proration with preventing a break in crude prices when the Illinois production came in; the market might have sunk to 10 cents a bbl., as it did after the discovery of Spindle Top and after East Texas came in. This steadying of the market is recommended to the attention of those who chafe at week-end shut-downs. The small man is protected because he can hold on to his property.

On the other hand, while production of crude was being held within reasonable limits, gasoline refining has gone wild.

Gasoline stocks on March 4th, 1939, stood at 85,000,000 bbl. A year ago, they stood at 92,000,000 bbl. No doubt the refiners could have by proper restraint kept stocks so that they would not have reached more than 82,000,000 bbl. by March 1st, and here they are with 85,000,000 barrels on March 4th. The chances are that they will run up to 95-100,000,000 bbl. before the consuming season gets under way. Those heavy gasoline stocks mean that gasoline prices will be affected adversely and that when gasoline prices break it is promptly reflected in crude prices. All which is grossly unfair to the producer who has shown his restraint.

The author, who was chairman of the Texas Railroad Commission, concludes by saying:

"We are going to try and put the refineries under control by statute just like production. There is no more sense in refining too much than in producing too much and it is much more dangerous to the price."

Basis of Proration in Texas—Wallace A. Pratt, before AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

The popular belief among oil producers makes of proration a form of curtailment designed to prevent overproduction of crude oil and thereby to secure and maintain higher prices and an assured market outlet for every producer. In contrast to this generally held concept, proration in Texas, where (despite the fact that it had its inception in Olkahoma) it has evolved farthest and has been applied most widely and drastically, rests solely on (1) the conservation laws for the prevention of physical waste of oil and gas, and (2) the police powers of the state for the protection of the citizen in his basic property rights. Any curtailment of production by agreement (except curtailment of agricultural production) is specifically prohibited by the anti-trust laws of the state.

Valid proration in Texas, then, merely prevents physical waste. It does not supersede nor set aside the law of capture. On the contrary, it functions fully within the operation of the law of capture. Nevertheless, it ameliorates effectively the excesses and inequities that have arisen out of the application of the law of capture in the past. Even the provision for limitation to market demand, frequently denounced by economists as an unsound and meretricious production control, is in fact justified as a means of preventing physical waste. Likewise, the prevention of physical waste as a function of oil-production engineering takes on a significance not generally recognized. In the absence of proration the prevention of physical waste becomes impossible.

If the industry persists in its attitude that proration is a device to be used by the individual states or by the Interstate Compact to curtail the production of oil for the purpose of stabilizing the industry or improving the price level, it will jeopardize the life of a concept which in preventing physical waste can render great service to oil producers.

Russia's Oil Problem—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 6 (1939), No. 16, pp. 193-196.

Although accurate information is not available, it is estimated that oil production in Russia in 1938 was slightly over 30,000,000 tons, of which some 28,000,000 were available to cover domestic requirements. Because of the enormous expansion of the Russian economy, the erection of great industrial plants, the motorization of transport, the development of civil aviation and the requirements of Russia's formidable armed forces, large and rapidly growing demands are being put upon the country's oil industry, demands which the industry is having great difficulty in meeting. The current Five Year Plan calls for a production of 54,000,000 tons of crude oil by 1942—an increase of 24,000,000 tons; considering the scale on which industries that consume petroleum products are to be concurrently developed, this program for the oil industry is a minimum rather than a maximum.

In view of the vastness of Russian oil reserves the production of 54,000,000 tons by 1942 is technically quite possible. However, such a result requires not only the intensification of operations in the older fields, but also the speeding-up of work in the newer producing areas; and this is contingent upon an adequate supply of drilling equipment and

other material, a large and capable technical staff and an efficient organization. It can hardly be claimed that these desiderata are at present at the disposal of the Soviet authorities.

To judge from the statistics, the prospect is not encouraging; in the last few years the rate of drilling has fallen off, although production has been maintained by reopening old wells. It appears that if the present plan is to be fulfilled production must be increased by five times its present rate.

To handle the planned crude oil output the capacity of the refineries is to be increased by no less than 15,000,000 tons by 1942 and it is planned to build cracking installations with an annual throughput capacity of 4,500,000 tons. During the final year of the third Five Year Plan refineries must be able to handle 125 percent more crude oil than at the end of the Second Plan, while the output of gasoline, is to be increased by more than 180 percent.

Parallel with these developments there are to be extensive additions to the transportation system, which is not the least formidable of the difficulties to be surmounted.

Altogether, this gigantic program will serve only to meet the country's growing internal requirements. There is no mention of any intention to revive the mineral oil export trade. The Russian authorities have been compelled in recent years to reduce exports to small dimensions, the total having declined from a peak of over 6,000,000 tons in 1932 to about 1,100,000 tons last year. Although it may be surmised that the Russians will not sacrifice their export trade altogether, it seems unlikely that a marked recovery will take place in coming years—if at all.

Judging by past achievements, it is difficult to avoid the conclusion that the oil industry has been set a tremendous task under the third Five Year Plan in order that the highest possible performance may be encouraged; even the authorities themselves can hardly imagine that the program will be completely fulfilled.

Relation Between Crude Oil and Product Prices—Sidney A. Swensrud, before ASSOCIATION AMERICAN PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

The study of the relationship between crude oil and refined product prices calls attention to the strong downward trend of petroleum prices and operating margins which has been going on for many years. In large part, it reflects the improvements that have been achieved in production, transportation and refining; but it probably reflects, too, a tendency toward declining profits as the industry matures and the rate of growth lessens. The market value of the refined products of crude oil has declined considerably more than the raw material itself. In the period since the beginning of 1927, the wholesale value of the refined products from a barrel of crude declined by an average of $1.26 a barrel as compared with the period from 1920 up to 1927. Between the same periods the price of crude declined by an average of 92 cents a barrel.

Thus it is apparent that in the period since 1927 the products of a barrel of crude have shrunk by 34 cents a barrel more than has the posted price of raw material from which they are obtained. It is to be borne in mind, also, that with the increased yield and quality of gasoline, the products of a barrel of crude today are relatively a more valuable combination requiring considerably more refining operations than the combination of products made in the early part of the '20s. So far as refining is concerned, there would seem to be nothing abnormal or alarming in the fact that the refining margin declines from time to time to unprofitable levels, for it is not the nature of the competitive system to permit comfortable and profitable operation to an industry all the time.

Likewise, there is nothing abnormal in the fact that the prices of refined products, being more sensitive, should reflect changes in the supply-demand situation for the industry as a whole more promptly than do crude oil prices. On the other hand there appears, in recent years, to have been an abnormal degree of postponement in the response of crude oil prices to adverse changes in the supply-demand picture for the industry as a whole and this tendency has operated to the serious disadvantage of the refining branch of the industry.

Petroleum Consumption during the Last World War—F. Friedensburg in PETROLEUM, vol. 35 (1939), No. 16, pp. 277-281.

This article is a condensation of salient facts discussed in the author's new book "Das Erdoel im Weltkriege" ("Petroleum in the World War," Ferdinand Enke, Stuttgart). So far as available statistics admit, the general picture is given by the accompanying table, which shows the mineral oil consumption of all the countries involved during the period of 1913 to 1918 inclusive.

COUNTRY	1913	1914	1915	1916	1917	1918
	(in 1000 Tons)					
Germany	1,388	820	700	1,210	1,410	1,470
Austria Hungary	700	720	430	420	620	850
Turkey	185	160	60	30	15	40
Bulgaria	35	32	22	11	5	11
Total Central Powers	2,310	1,730	1,210	1,670	2,050	2,270
Specific Military Consumption	.....	.....	.....	.....	.....	2,270
Great Britain	2,094	3,000	3,200	3,700	5,350	6,200
France	707	600	593	734	809	865
Italy	275	273	318	368	402	466
Russia, total	8,243	8,900	9,000	8,500	8,200	3,000
Russia, military	.....	100	200	250	150	.....
Roumania, total	850	1,150	1,244	1,044	.....	.....
Roumania, military	.....	.....	.....	50	10	10
U. S. total	29,696	32,820	33,598	36,012	41,775	46,125
U. S., military	.....	.....	.....	.....	1,000	1,450
Smaller nations	.....	5	10	10	10	10
Total Entente Military Consumption	41,865	46,743	47,973	50,378	56,556	56,676
	.....	.....	.....	.....	.....	9,000

The greater military consumption of petroleum products by the Entente Powers is accounted for not only by the fact that they had an abundant supply, but also by the fact that they had a far greater mechanical equipment than the Central Powers. Near the end of the war the Entente had about 200,000 motorized vehicles on the western front alone, of which 92,000 were trucks in transport service. At the same time the Central Powers had a total of about 40,000 such vehicles, half of these being on the western front. At the time of the Armistice the Entente had 3,500 tanks and the Germans 45. At the beginning of hostilities the Germans had 252 combat airplanes; during the war they built a total of 47,600 aircraft and at the end had about 5,000. France began with 132 planes and ended with more than 12,000; throughout the war the average ratio of air strength was 3:1 in favor of the Entente; toward the end this ratio became more unfavorable to the Germans, especially on the minor fronts.

By far the greatest consumption of oil was for naval and other forms of water transportation, particularly by submarines and the swarms of submarine chasers and convoy ships. In oil-propelled water-borne tonnage the Entente had a superiority of 10 to 1. In the last year of the war the allied fleets were consuming oil at the average rate of 470,000 tons a month, and this consumption was rising toward a 1,000,000 tons at the end.

However, in the matter of land transport, especially behind the western front, the Germans found some compensation for their lack of motor fuel in their more highly developed railroad system, for which they had adequate supplies of coal.

From these considerations it may be suggested that the amount of oil consumed in the next war, aside from the still unknown factors of air and tank operations, will again be determined mostly by the requirements of naval operations and water transport and also on the ability of the combatants to produce and replace oil-using equipment.

U. S. Oil Industry's Foreign Markets for Crude Oil and Gasoline—Oskar Tokayer, in PETROLEUM PRESS SERVICE, vol. 6 (1939), No. 18, pp. 217-220.

While the main trends in the development of U.S. oil exports as a whole are generally well known, details of their distribution are much less familiar. Figures of crude oil and gasoline exports for the past five years are given.

U. S. Crude Oil Exports

(Thousand Barrels)

	1938*	1937	1936	1935	1934
Canada	24,845	28,080	25,683	24,412	21,958
Japan	21,290	15,995	10,394	10,483	6,693
France	16,743	10,066	7,463	10,348	10,904
Italy	6,751	4,544	1,807	1,607	446
Argentina	1,504	1,420	1,284	1,112	769
Germany	1,223	1,430	1,176	1,531	380
Sweden	930	363	404	270	66
Belgium	349	449	67	93	102
Netherlands	326	309	210	151	‡
United Kingdom	153	753	160	411	‡
Other countries	3,158	3,718	1,536	1,012	504
Total	77,272	67,127	50,184	51,430	41,122

* Preliminary figures. ‡Under 500 bbl.

U. S. Gasoline Exports†

(Thousand Barrels)

	1938‡	1937	1936	1935	1934
United Kingdom	9,952	5,548	3,650	5,146	4,532
D.W.I.	4,852	3,629	831	662	1,396
France	3,785	2,358	998	2,343	1,484
Canada	3,274	1,735	579	932	1,734
Netherlands	2,417	2,213	1,147	928	813
Sweden	2,390	826	455	1,048	805
Germany	2,305*	1,179*	614	744	329
Spain	2,095	823	2,056	1,902	899
Australia	2,049	1,917	1,881	2,233	2,142
Russia	1,546	1,544	546	.....	.....
Brazil	1,476	1,429	1,161	1,142	972
Japan	1,447	1,403	906	699	1,079
Belgium	1,311	2,141	1,442	1,561	1,480
Others	8,916	9,135	7,438	7,615	5,523
Total	47,815	35,880	23,704	26,955	23,188

† Including natural gasoline, naphtha solvents and mineral spirits.
* Including Ostmark (Austria). ‡Preliminary figures.

As shown by general statistics not quoted here the shipments of crude oil from U.S.A. accounted for more than 35 percent of all exported liquid petroleum products; the table here given shows who are the principal foreign buyers of American crude oil. Ninety percent of the 1938 total went to four countries—Canada, Japan, France and Italy, in that order. Canada is easily first on the list with 32.2 percent, but it is imports by France, Japan and Italy that contributed to the increase of 1938 shipments over those of 1937. The Canadian takings of crude have declined, evidently due to the remarkable increase of oil production within the Dominion. Next to Canada, Japan is the principal customer for crude oil, with 27.6 percent of the total shipments, followed by France with 21.6 and Italy with 8.7 percent of American crude oil exports.

In contrast to crude oil exports, which go mainly to a few large importers, American gasoline goes to almost all countries of the world. The peak of gasoline exports occurred in 1930 with 62,000,000 bbl., followed by a low point of 23,000,000 bbl. in 1934; the 1938 figure shows a total of 47,815,000, including about 6,000,000 bbl. of natural gasoline, exports of which were insignificant in 1930. These fluctuations were in part due to new American tariff duties on Netherlands West Indian gasolines, which had to seek other markets in competition with American gasoline, and in part to increased exports from Russia and Roumania; these latter countries have declined in importance as gasoline exporters, and within the past two years conditions are again in favor of the United States.

At present the United Kingdom is taking about a fifth of American gasoline exports; Netherlands West Indies are buying increased amounts of

natural gasoline for blending purposes. Canada is also taking more, in spite of a great increase in the production of crude oil.

Effect of Capacity on the Cost of a Cracking Plant—W. L. Nelson, in OIL AND GAS JOURNAL, vol. 37 (1939), No. 45, p. 80.

The type of plant studied herein is the distilled-oil recirculation type. The cost of black-oil recirculation plants will be somewhat higher although the choice of contractor may be even a more important consideration from the standpoint of cost. Three plants operating on a 24 A.P.I. Mid-Continent reduced crude oil, were designed for capacities of 750, 1,500 and 3,000 bbl. per day of reduced crude oil—and in addition two other designs of 1,500-bbl. plants operating on 21 and 27 A.P.I. stocks, were introduced in some comparisions. All of the plants were designed for the same general operating conditions and of comparable materials.

Figuring the sale price of raw gasoline at four cents per gallon and fuel oil at 50 cents per bbl. the general picture is as follows:

Capacity Bbl./day	Gravity of Stock, API	Value of Stock cents/bbl.	Cost of Plant $	Yearly expense $	Yearly Profit $
750	24	55	148,908	274,000	6,500
1500	21	50	195,049	476,000	60,000
1500	24	55	203,310	525,400	36,000
1500	27	60	206,643	572,500	14,800
3000	24	55	288,816	1,024,000	86,000

Such capacity items as stills, towers, condensers and insurance, all constitute larger percentages for the 3,000-bbl. plant but by no means in direct ratio to plant size. In fact, in the case of pumps and piping the percentages of the total cost of the 3,000-bbl. plant is scarcely larger than for the smaller plants. Other items such as instruments, tools, drafting and supervision are no greater for a large plant than for a small plant and hence they constitute a smaller percentage of the total cost of the 3,000-bbl. plant than for the smaller plants.

In addition to the high cost of a small plant, such a plant is also penalized during operation by high supervision costs.

In order for the small refiner (750 bbl.) to make a profit of 10 cents a barrel from his operations he would have to obtain reduced crude oil at a price of about 47 cents rather than 55 cents a barrel. Or the same result could be accomplished by selling his raw gasoline at about 4⅜ cents rather than 4 cents per gallon. The latter would be almost an impossible situation to attain because 4.38 cents plus treating costs is more than the market will normally bear.

Wildcat Drilling in 1938—Frederick H. Lahee before ASSOCIATION AMERICAN PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

This report covers only the states of the coastal plain area, from Texas and southeastern New Mexico to Georgia and Florida. A wildcat is again defined as a hole drilled completely outside the known boundaries of pools already developed and far enough from producing areas to be essentially a test of new possibilities.

In this area during 1938 a total of 5,651,664 ft. was drilled in 1,471 holes, divided between 200 producers with 984,262 ft. and 1,271 dry holes with 4,667,402 ft. This means that 13.6 percent of the holes and 17.4 percent of the footage drilled was successful.

Comparison with figures for preceding years shows a steadily increasing percentage of producers and of footage drilled in producers, and a decreasing footage drilled in dry holes for every producer foot. It also shows a steady increase in the number of wildcat wells drilled each year and in the average depth per hole.

As for the reasons for drilling in 1938, 68 producers and 531 dry holes were located on geological information (surface, subsurface, trend, core drilling); 50 producers and 174 dry holes were located on geophysical evidence (seismograph, torsion balance gravitimeter, magnetometer, resistivity); 10 producers and 36 dry holes were located on combined geological and geophysical evidence; three dry holes were located on other technical evidence; and 14 producers and 292 dry holes were located for non-technical reasons (lease requirements, promotion, hunch, shows reported in old wells, etc.).

Of the holes located without technical advice, 4.54 percent were producers, whereas 14.67 percent of the holes located on technical evidence were producers. The fact that less than 15 percent of the wildcats drilled on technical advice found oil or gas is significant of the uncertainties of geology and of the consequent difficulties of imterpretation of available technical data. The impressive thing is that the holes located on technical advice were 3.23 times as successful as those drilled without such advice.

As a result of all this wildcat drilling, many new pools were discovered, 96 in fact. This was more than were found in 1937, and considerably more than were found in 1936.

Analysis of Crude Oils from Some Fields of Oklahoma—O. C. Blade, in BUREAU OF MINES REPORT OF INVESTIGATIONS, No. 3442, April, 1939.

Three groups of crude oils, including samples from I, Oklahoma City and vicinity, II, the Seminole district and III, miscellaneous, were analyzed, and the results are compared with data obtained in previous analyses. The samples previously examined were classified as follows: 58 intermediate, seven paraffin-intermediate, and one paraffin-base crude oil. In the present series, 27 intermediate, 15 paraffin-intermediate, and two paraffin-base oils are shown. Although there are a number of borderline cases where a slight difference in the gravity of a key fraction would change the results, the study shows that as newer areas were opened there has been an unmistakable trend toward the production of a more paraffinic type of crude petroleum in Oklahoma.

Motor Ships—J. Cazalis, in REVUE COMBUSTIBLES LIQUIDES, vol. 17 (1939), No. 163, pp. 87-90.

The latest edition (1938) of Lloyds Register shows that among the 27,800 ships of the world that are mechanically propelled and have a total tonnage of more than 66,500,000 tons, 5,353 are motor ships with a gross tonnage of 14,930,000 tons. This represents a quite perceptible increase over the figures for 1937, when the figures showed 4,793 motor ships with a gross tonnage of 13,395,000 tons. In spite of losses and demolitions motor ships show a gain of about 600,000 tons relative to the total of all ships.

	Motor Ships	
YEAR	Number	Gross tonnage
1923	824	1,321,131
1924	953	1,654,546
1925	1116	2,403,070
1926	1302	3,197,943
1927	1476	3,991,123
1928	1808	5,153,116
1929	2069	6,343,056
1930	2476	7,816,159
1931	2829	9,158,424
1932	3100	9,760,488
1933	3271	9,914,183
1934	3488	10,314,515
1935	3856	10,989,886
1936	4293	11,953,764
1937	4793	13,395,137
1938	5353	14,929,732

Examination of these figures shows a period of active construction in 1927-31, during which the increase of tonnage was more than 5,000,000 tons; more recently the four-year period 1935-38 witnessed the launching of 4,000,000 tons of motor ships. Reports as of September 1938 show a total of 762 ships under construction with a total horse power of 2,933,243 h.p., 486 of these ships are to be driven by internal combustion engines rated at 1,951,603 h.p. The principal countries now building are Germany, Great Britain and Holland. However, of all the motor ships now in service more than a half are under the flags of two nations: Norway, and Great Britain.

RESERVES

Crude Oil Reserves of Texas Panhandle—Henry Rogatz, in OIL WEEKLY, vol. 92 (1939), Nos. 5, 6, 7.

This study covers a large amount of detail. The productive formations of the Texas Panhandle are found in three dolomitic zones (B, C^1 and C^2), two granite wash zones (E^1 and E^2) and an arkosic zone (D). From all the data available the following picture is presented (figures in bbl.):

Formations	Estimated Reserves	Average Reserves per Acre	Ultimate total	Recovery per Acre
B	4,820,350	3,893	6,021,890	4,864
C^2	126,329,521	4,058	200,356,309	6,436
C^1	323,053,489	7,127	369,828,896	8,146
D	57,221,968	2,960	94,743,745	4,901
E^2	105,562,916	3,810	177,905,395	6,421
E^1	123,715,541	5,261	184,046,114	7,827
Total	740,703,785	4,994	1,032,902,349	6,964

There are still many areas in the Panhandle which possess potential possibilities of commercial production and therefore are worthy of exploration. In many instances the uncertainty of the possibilities lies not in their questionable structural location but rather in the questionable character of the producing formations which makes it difficult to determine with any degree of accuracy the chances for the discovery of oil or the probable extent of these likely discoveries.

Among the unexplored possibilities, there are recognized two types of production: (1) Shallow, or production from formations of the same age as now producing (Permo-Pennsylvanian); (2) Deep, or production from pre-Pennsylvanian formations, most likely Mississippian or Ordovician.

With regard to the shallow possibilities, there are reasonable opportunities in practically all of the five oil producing counties, as well as southeastern Hartley County. The most favorable and at the same time the most uncertain, is Moore County.

GENERAL

Elimination of Calcium Carbonate Deposits from Industrial Waters—Owen Rice and Everett P. Partridge, in INDUSTRIAL ENGINEERING CHEMISTRY, vol. 31 (1938), No. 1, pp. 58-63.

Deposition of calcium carbonate from bicarbonate waters used as cooling media in condensers or heat exchangers is a widespread industrial problem, as is the after-precipitation of calcium carbonate in filters and pipelines following lime and lime-soda softeners. To obviate formation of these deposits, various methods have been employed in the past, involving use of tannin, partial neutralization with acid, or recarbonation, or deposits have been periodically removed by mechanical means or by dissolving them in acid.

A new method, developed within the past two years, depends upon the fact that soldium hexametaphosphate, present in the water to the extent

of only a few parts per million, will prevent precipitation when a high-bicarbonate water is treated with alkali or heated to a temperature not exceeding the boiling point. This threshold treatment has been applied successfully to remove old deposits as well as to prevent new ones in railroad, industrial, and municipal water-softening plants and distribution systems, and in power-plant, distillery, and oil-refinery condensers.

In once-through systems a continuous feed of from five to as little as one pound of sodium hexametaphosphate per million pounds of water is employed. Where cooling water is recirculated through a spray pond or cooling tower, an amount is introduced in the make-up sufficient to maintain a similar range of concentrations in the circulating water.

An advantage of the threshold treatment is the relatively high pH which may be maintained in order to decrease corrosion without causing precipitation of calcium carbonate.

Safety at the Baton Rouge Refinery—Eric H. Brown, in Information Circular 7059, U. S. BUREAU OF MINES, March, 1939.

The author outlines the safety policies at the Baton Rouge refinery of the Standard Oil Co. (La.), which now has an output of 100,000 bbl. of crude a day, ships 20,638 tank cars of petroleum products a year and 30,000,000 bbl. by tank steamer, and normally employs 4,200 men. Instructions in safety measures and first aid work is thorough and much effort is devoted to render the men safety conscious. The result has been a marked improvement in the accident record since the safety department was organized in 1920. This may be seen by comparing the figures of 1920-22 inclusive with those of 1935-37 inclusive.

Year	Frequency rate	Man-hours of exposure
1920.....	68.42	8,725,440
1921.....	41.42	9,680,968
1922.....	31.24	9,602,128
1935.....	2.94	6,795,706
1936.....	2.78	7,896,820
1937.....	3.08	7,453,730

The refinery was awarded in 1938 the Joseph A. Holmes Safety Association award for continued safety in operation for several years.

BOOKS

Molybdenum Steels in Oil Production—Issued 1939 by CLIMAX MOLYBDENUM COMPANY, New York; 30 pages.

This pamphlet describes the physical properties of a variety of Molybdenum steels: chromium-molybdenum, manganese-molybdenum, nickel-molybdenum, nickel-chromium-molybdenum, silicon-molybdenum, and castings made from these alloys. These various steels are used for various kinds of oilfield purposes, depending on the conditions to be met in various operations. The pamphlet gives information which will assist the petroleum engineer to make the proper selections.

Miocene Stratigraphy of California, by Robert M. Kleinpel; published 1938 by AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, Tulsa; 450 pages, with numerous maps, figures and stratigraphic charts. $5.00.

This work establishes a standard chronologic-biostratigraphic section for the Miocene of California and compares it with the typical stratigraphic sequence of the Tertiary of Europe. It is based largely on foraminifera, of which there are 22 full tone plates. The book, into the preparation of which an immense amount of labor has evidently been put, will be a distinct help to those who are interested in this portion of the earth's crust, as well as to micropaleontologists in general.

A.S.T.M. Standards on Petroleum Products and Lubricants, prepared by committee D-2, Published 1938 by AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia. 311 pages in double column format. $2.00.

The 1938 edition of the A.S.T.M. Standards on Petroleum Products and Lubricants gives in their latest approved form 61 test methods standardized by the Society through the work of its Committee D-2 on Petroleum Products and Lubricants, eight specifications, and two lists of definitions pertaining to materials for roads and pavements. Several new standards are given for the first time, including tests for acid heat of gasoline, ash content of petroleum oils, and tests for plant spray oils. The new specifications for Stoddard solvent approved in 1938 are also included. For information and to stimulate comment there is given a proposed method of test for ignition quality of Diesel fuels.

In addition to the large number of standards pertaining to petroleum products, there is also included the current report of Committee D-2 itemizing numerous changes in the standards, and giving the latest revised Diesel fuel oil classification.

Les Gisements de Petrole (Petroleum Deposits), by Georges Macovei, published 1938 by MASSON ET CIE, Paris; paper, 502 pages with 222 figs.; 120 francs.

This is a text book on oil geology, in French, written by the chief of the Roumanian geological survey, who is also professor at the Ecole Polytechnique at Bucharest. It gives a survey of theoretical and practical oil geology, drawing illustrative material from many parts of the earth. It will of course be of chief interest to students who speak French; Alglo-Saxons will find it interesting as giving some idea of European views of the science. Particular attention is naturally given to what students may see in Roumania and nearby countries.

Pipe Corrosion and Coatings, by Erick Larson; published 1938 by AMERICAN GAS JOURNAL, New York; 468 pages, 5½ x 8½ inches, with 160 illustrations, $2.50.

This book provides a survey of the theories of corrosion now current and the practice of pipe protection as developed in various parts of the earth; to this store of recorded knowledge the author has added his own extensive experience with the engineering of gas distributing systems and as a member of national and state committees for investigating the subject. The 28 chapters cover the fundamental notions of chemical and electrolytic corrosion soil testing and analysis, soil corrosion surveys, the necessary qualities of protective coatings, the different kinds of coatings in use and methods of their application, cathodic protection, etc. The author has done what can be called a fairly complete job of presenting the subject. The book is quite readable, and at all points is kept within the comprehension of practical men who are interested in underlying reasons as well as answers to the problems that confront them.

Engineers' Piston Ring Handbook—issued by KOPPERS CO. (American Hammered Piston Ring Division), Baltimore: 4th Edition, 158 pages.

This is a practical manual giving recommended types, specifications and applications of piston rings for machine designers and operators. It describes 42 types of piston rings for all purposes. The diversification of the piston ring art is indicated by the fact that bronze rings and cast iron rings are cast in as many as 30 different alloys to meet the demands of various services. As is well known, piston rings and lubricating oil are inseparable companions, which may be a reason why oil producers should know something about piston rings.

Fundamentals of the Petroleum Industry, by Dorsey Hager; published by MCGRAW-HILL BOOK CO., New York; 445 pages, $3.50.

This book, written by a consulting geologist and petroleum engineer with 28 years experience, is intended to present a comprehensive outline of the petroleum industry and its problems, supplementing the existing texts that cover the various specialized branches of the business.

The author has accomplished his object of presenting a comprehensive statement of how the petroleum industry goes about its business, and his book can be recommended to those who need a birds-eye view that is not overburdened with details and yet not so sketchy as to overlook any important angle. He begins with an outline of petroleum's contribution to the national well-being, summarizes the history and romance of oil, identifies the principal companies and individuals of oildom, surveys the world's oil resources, explains leasing and royalties; the function of engineering in searching for oil; the roles of the driller, the production engineer, the refiner and the marketer, winding up with the business of oil, oil securities and legislation; altogether it is a well-balanced birds-eye survey and is worth reading by any non-technical person who wants to know something about petroleum.

Elements of Fractional Distillation, by Clark Shove Robinson and Edwin Richard Gililand; 3rd Edition, Published 1939 by MCGRAW HILL BOOK CO., New York, 267 pages; $3.00.

The new edition of this standard work follows the original plan of showing how the principles of fractional distillation may be applied to particular problems according to the best ideas of physical chemistry and chemical engineering. The factors involved in plant design are considered and illustrated by examples. Chapters are given to the rectification of complex hydrocarbon mixtures, rectification of absorption naphtha, and topping stills for crude petroleum. Tables, graphs and an index close the book.

Oil-Well Cementing Guide; issued by UNIVERSAL ATLAS CEMENT CO., New York, 150 pages, with numerous figures; free.

Issued as a trade publication this work is the first book to give a comprehensive treatment to oil-well cementing operations. The text is divided into three parts. Part I consists of nine chapters which deal extensively with the various phases of oil-well cementing, with reference to the different conditions encountered on many jobs; Part II deals with cement and concrete used for construction purposes in oil fields, and Part III describes the publisher's products. A glossary of terms used in oil-well cementing and an index are provided.

One chapter is devoted to "Determining the amount of cement to fill annular spaces," and accompanying this chapter are three alignment charts by which such calculations can be made graphically and quickly.

The petroleum industry is now using approximately a million bags of cement a month for oil-well cementing east of the Rocky Mountains, and it is about time that a treatise of this kind should become available.

Russian Oil Survey—Part III

Third of a Series Dealing with the Soviet Petroleum Industry in All Its Phases. Baku and Grozni Have Been Dealt with in Previous Issues, While This Article Surveys the Maikop Oilfield Group, Third Largest in Russia. Next Month Mr. Wegrin Discusses Daghestan and the Other Fields of the Caucasus.

MAIKOP

THE THIRD largest oilfield of the U.S.S.R. is Maikop, in the Kuban province of north Caucasus. It is bordered in the south by the main Caucasian range, in the east by Daghestan, and in the west by the Black Sea.

Physiography—

About 65 percent of the territory consists of forest lands with steppes along the edges of the mountain ranges, which are rich in mineral wealth including silver, lead, mercury, coal, marble, ozokerite, mineral springs, oil and gas. The town of Maikop, which is situated on the Belaya river, is quite modern. The summers are warm and the winters mild. Maikop is connected by rail to Armavir and Tuapse, tidewater port on the Black Sea.

History—

The Maikop oilfields are essentially a recent development, for although oil was being produced by primative means as early as 1821, the total output for the period up to 1900 was only about 2,500 tons. Development of the area began between 1907 and 1912 when several wells drilled to depths of 1,000 to 1,500 ft. resulted in producers of clean, light oil under fairly strong pressures.

By 1910 a number of wells were in operation and British finance took an interest in the development of Maikop. During the prewar period the wells were drilled to depths between 800 and 1,800 ft. and were of short duration; because of inadequate geological studies the extension of the field proceeded slowly, and development was generally interrupted by the war of 1914. When rotary drilling was introduced by the Soviets in the postwar years Maikop seemed to offer even greater encouragement, but experience was still lacking and due to the extremely volatile nature of the crude the fire hazard was considerable.

Composition—

The original oilfields consisted of Apsheronskaya, at the town of Maikop, and

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Khadizenski, some six miles west of Maikop. Both are similar as to formations and the length of the combined fields was about 18 mi. The two comparatively small fields were at first quite separate, and due to their inaccessibility it was not at first possible to prove their relation by geological study.

The lack of roads and uncertainty as to the importance of the Maikop fields at first retarded their development but the high grade of the crude and the necessity of meeting the increasing demands for oil, served as an incentive. Grozni was at the time believed to be approaching exhaustion, and hopes were laid upon Maikop to replace the impending loss of production. The late Prof. I. Gubkin was leader among the geologists who declared that the Kuban province contained more petroliferous areas than the two existing fields.

Geology and Stratigraphy—

All Caucasian fields from Baku through Daghestan and Grozni to Kuban are interconnected by Tertiary formations which girdle the Caucasus Mts., and the folds are linked by exits of oil and gas. In the eastern part of Kuban, of which Maikop is part, the deposits are basically of Paleogene formation, while in the western sector oil is encountered in a broader complex from Eocene to Paleocene, while deposits in the Miocene and Pleocene are secondary and formed by migration from the Maikop layers and other foraminiferous compacts which were the main oil-bearing formations in the Kuban. It was from this standpoint that further studies were made.

Apsheronsk and Khadizenski were studied geologically and as similarities were found in the tectonics of each the two properties were combined and extended to form one unit on a line of about 32 mi. Further studies showed that the field could be extended much further and many more properties were prospected with promising results.

There are two definite oil-bearing complexes in Maikop territory: (1) the Maikop section rich in deposits, under which heading come the Aspheronsk-Khadizi properties; and (2) petroliferous sections of the Mesozoic formations which are under study and part operation.

(I) KUTAISKI REGION—This is territory some 14 mi. west of Khadizenski and about nine miles from the Kutaiski railroad station. The formation is monoclinal dipping 37 deg. northeast at an angle of 20 to 27 deg. The thickness ranges from 580 ft. in the northwest to 1,240 ft. in the east. The upper and lower parts of the Maikop sand are represented by clay formations; rusty brown and yellow gray sand with layers of spongolites in the eastern part while in the northwest the sands and spongolites disappear and are replaced by foraminiferous matter. The lower Maikop consists of clay intermixed with layers and lenses of claysand, loose clay immediately overlapping the washed up foraminiferous layers.

Production Figures Maikop (tons)

1908	2,500	1924	52,500
1909	12,400	1925	66,100
1910	22,200	1926	68,400
1911	128,800	1927	66,900
1912	150,600	1928	88,900
1913	79,600	1929	139,600
1914	67,200	1930	505,600
1915	127,900	1931	530,600
1916	36,100	1932	910,000
1917	41,700	1933	500,800
1918	61,600	1934	940,000
1919	48,900	1935	1,179,000
1920	15,700	1936	1,200,000
1921	32,800	1937	1,650,000
1922	42,300	1938	2,000,000
1923	43,900		

Under an analogy with Khadizenski, where the solidity of the sand spongolite formations increases downwards with the dip and yield from 100 to 400 tons of crude per well per day, the Kutaiski deposits are at greater advantage owing to increased thickness of these similar formations. Several drillings at Kutaiski struck also the middle layers at 1,000-1,200 ft. and encountered a flow of oil containing 52 percent light products which is more than in the Khadizenski wells. At places in the middle Maikop a zone of ammodiscus and goplapharagmoides were noted for the first time. In the foraminiferous layers the presence of Lyrolepis caucasica Rom were encountered which were also previously unknown there.

ASPHALT MOUNTAIN is situated between Kutaiski and Khadizenski at a distance of about six miles from the latter, the region includes not only the mountain but a large area which is of Maikop formations coinciding with those at Khadizenski. The middle layers are the Asphalt Mountain sections, represented by sand spongolite faces as at Khadizenski. The thickness reaches 300 ft. but is quite irregular. On the eastern incline of the mountain these formations are at maximum and decline to the west and disappear, but come back at places further west. The only disadvantage of Asphalt Mountain is its dip of 57 deg. However, it has been a considerable contributing factor to the increase of crude production of Maikop fields.

THE WATERLESS DAGHESTANSKI is an area immediately east of Shirvanski, having the river Pshekha in the west and estuaries of the river Kurdzips in the east. Here the Maikop monocline consists of four horizons. The lowest is a horizon of gray and ash gray laminated pyrite clays 120 ft. thick, above which is a horizon of dark brown bitumen clay and siderite sands 450 ft. thick. The next horizon is of dark brown pyrite and other clays 330 ft. thick while the shallowest is a horizon of dark

gray calcareous clays Planorbella sp. 45 ft. thick. The latter horizon was encountered beyond the bank of Pshekha river, and was absent in the other locations of the Waterless Daghestanski. The second horizon overlies the various suites of the lower formations down to the calcareous layer.

This region is under assidous study and prospecting and is bound to become an important field.

ABDSEKHO-DAGHESTANSKI REGION. This territory is east of Waterless Daghestanski. The tectonics are monoclinal and the formations dip northerly under an angle of 5-10 degrees. The Maikop here is well represented in similarity to Khadizenski and subdivided into two three layers similar to the lower Maikop, which is the light oil depository. Analogies to the corresponding Maikop formations at Apsheronsk-Khadizenski were found, and in the western area bordering Waterless Daghestanski the Lower Maikop is entirely absent, represented instead by conglomerates of gravia. The aggregate thickness of sandy formations is 90 ft. Further studies and explorations are now in progress.

KURDSHIPSKI REGION is a brakhi anticline fold all latitudinal about four miles north of Maikop and nine miles from Abdsekhski, where the Maikop formations crop out to the surface. The axis of the fold has two dome-like fillings; in the east the Tulski dome is formed in spaniodotelous layers and to the west is the Kurdhip dome. The northern wing is inclined north-northeast under an angle 4-5 deg. and the southern wing is inclined south-southwest under an angle of 2-3 deg.

ABADSEKHSKI-BATALAPSHINSK. East of Abadsekhsk on the eastern border of Maikop a series of unstudied Maikop formations stretches over a line of 90 mi. Compared with the Maikop formations in the other regions of Kuban this strip of land is represented in more developed sand sediments by virtue of which the formations are similar to Shirvanski properties and surveys at Batalpashinsk had shown the Maikop to consist of four layers (working up): dark brown pyrite and shell compacts of clay, 180 to 240 ft. thick; sand clay sediments alternating in sand and dark brown clay with Promerluceinis sp. and other fish remnants; clay sand series alternating in dark brown and gray clays and small grain sands up to 18 ft. in thickness—here were encountered lepidopus ex. gr., leptospondilus Beck, Nemopterik sp. and other species and foraminifera 300 to 450 ft. thick; and dark brown pyritic light calcareous clay intermixed with marly. Encountered were Pelecypoda, Ostrocoda and Foraminifera (the latter were absent in marly) and a second group of dark brown and gray pyrite clay becoming downwardly

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greenish gray with planorbella sp. about 120-150 ft. thick.

These characteristics are similar to those of Shirvanski as well as with those of Apsheronski-Khadizenski formations of the Maikop layers. The last two horizons have layers of bituminous clays.

(2) The Mesozoic formations in the territory of Maikop were studied since 1932 and it was established that four regions exist of which three are in the north Caucasus.

ABADSEKHO-SEVASTOPOL, about 15 mi. south of Maikop, is represented in a monoclinal consisting of chalk and Paleogene sediments with an angle of depression five to ten deg. No oil was found in the lower horizons of chalk, but indications were present in the form of thermal and sulphur springs containing hydrocarbon gases.

KUBAN-ARMEMNIAN REGION is situated between the river Pshekha in the east and the oilfields of Apsheronski in the west, bordering in the north with the Mesozoic and Tertiary sediments about four miles from Neftgorsk. Three horizons were studied: the lower represented in dark brown non-and lightly calcareous clays, the middle or sand clays with individual lenses of loose sands and sandstones, and the upper as clay sands alternating with considerable fauna pelecipod.

The third region is SAKHRAISKI, about 18 mi. from Abadesekhski-Sevastopol, which was not surveyed before at all. To this group belongs further the region of the southern slope of the Caucasus which is represented at Sochi on the Black sea, but this region does not come under Maikop.

A. Krems, a noted Soviet geologist, summed up the possibilities of Maikop in the following:—northwest from the Terski hills many interesting results were obtained in prospecting which made possible the commercial development of the Kutaiski, Kurazepe and Asphalt Mountain properties of Maikop. These new regions monoclinal formations in which oil is linked with the formation of the Maikop layer. Drilling was employed in surveying the fields when they were prepared for commercial operation subsequent to 1936. The indexes were at Kutaiski: at 2,355 ft. the flow was 25 tons of crude per day; at 2,790 ft. wells were flowing 500 tons of crude daily. At Kurazepe from 1,275 ft. wells gave 20-25 tons of crude per day while at Asphalt Mountain the first wells were 1,476 ft. deep flowing 50 tons per day. Thus during 1937 Asphalt Mountain, Kutaiski and Kurazepe came in as commercial oilfields. With the existing Apsheron-Khadizenski fields the entire group forms an oilfield on a line from Maikop of 36 mi. These fields yielded 1,100,000 tons of crude in 1936 and in 1938 2,000,000 tons.

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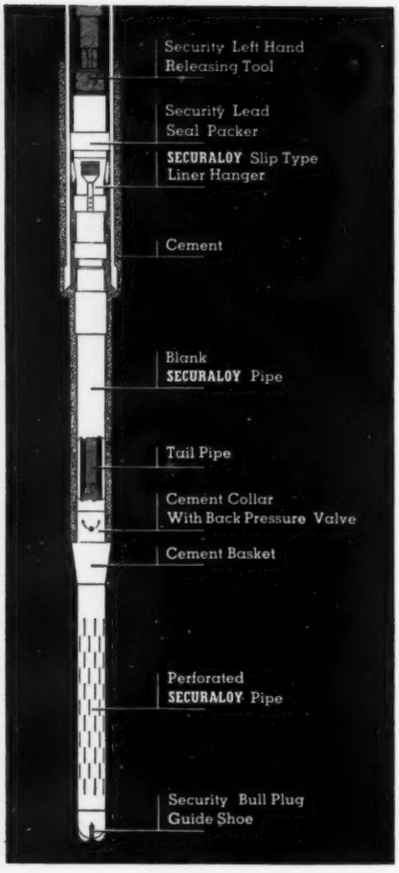

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The main producing horizon in the Maikop fields is the "C" horizon and the oil wells are rich in gas and there also are dry gas wells.

About 50 percent of Maikop oil wells are under gas/lift. Gas/lift is generally the Saunders system with the usual pipe diameter three inches and at some four inch pipe is used. With the usual average production of 50 tons of crude per day the pressure of gas/lift is for 2½ inch 15 Atmos., under three inch pipe 11 Atmos., and with four inch pipe seven atmospheres. Total gas consumption is 25,000 cu. m. per day and the average pressure is eight atmospheres.

The average depth of wells at the Apsheron-Khadizenski and Kutaiski regions is 2,600 ft., at Kurazepe it is 1,500 ft., and at Asphalt Mountain 1,400 to 1,500 ft.

The natural gases of Maikop are generally rich in propane and butane, which to some extent enter its natural gas gasoline. The presence of Ethane from 10 to 23 percent qualifies these gases for carbon black manufacture.

The deposits of Maikop as estimated before the new Kuban oil land were taken into consideration were 80,000,000 tons of immediately workable and visible deposits.

Maikop has on record, a well drilled to 6,500 ft. which yielded crude containing 40 percent of gasoline. During recent years Maikop has been leading other Soviet fields in erection of derricks and speed of drilling as well as in quality. Speed of about 3,000 ft. per table month has become a common practice. With the extension of the original Apsheronski-Khadizenski fields to northwest and south, the spacing of wells as a rule is two hectares or more per well. All drilling is done by the the rotary method and all old equipment has been gradually renewed with more modern tackle.

Maikop has a number of carbon black installations and natural gas gasoline plants. At Krasnodar, about 60 mi. from Maikop, there is a refinery with a capacity of about 22,000 bbl. of crude daily. The total crude production which at the present rate is about 2,500,000 tons per year is carried for processing to Krasnodar and Grozni. The Krasnodar refinery is to be enlarged in 1942 and is expected to become a refining center for Maikop.

Pipeline facilities of Maikop consist of one 60 mile line of eight inch pipe to Krasnodar, having 1,000,000 tons crude capacity per year; new lines are to connect the fields of Kutaisk, Asphalt Mountain, etc., with Maikop. Maikop also is connected with the Grozni-Tuapse trunk line bringing Maikop to tide water on the Black Sea.

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